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PAPERS AND PROCEEDINGS OF THE
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JOINTLY WITH THE JEFFERSON COUNTY MOSQUITO
CONTROL ASSOCIATION
BEAUMONT, TEXAS, FEBRUARY 5-7, 1956

PART 2

TEXAS MOSQUITO PROBLEMS FROM A SPECIES STANDPOINT

R. B. EADS AND G. C. MENZIES *

Entomology Section, Bureau of Laboratories, Texas State Department of Health, Austin

Marked diversity in geographical and ecological factors in Texas account for a wide range of generic and specific variation in the mosquitoes present. The rain forest pools, permanent ponds and lakes of East Texas; the salt marshes and rice growing regions of the Gulf Coast; the semi-tropical Lower Rio Grande Valley with its vast acreage of surface water; and the irrigation areas of arid West Texas produce a mosquito fauna characterized by numerous species and large populations. Texas State Department of Health records currently include approximately 75 species, exclusive of subspecies, which have been collected in the state, 8 of which do not appear to be permanently established elsewhere in the United States.

Historically, mosquito control in Texas has been motivated chiefly by efforts to control malaria and dengue; hence, species control has been directed against *Anopheles quadrimaculatus* in East Texas and the Lower Rio Grande Valley and *Aedes aegypti* in the larger cities. The gradual disappearance of malaria as a disease of consequence and the fact that the most recent outbreak of dengue occurred in

1941 have considerably lessened enthusiasm for controlling these species, although both are still quite abundant in certain sections of the state.

Population studies conducted by W. E. Burris, Aquatic Biologist, Corps of Engineers, in the vicinity of nine reservoirs in the Fort Worth district have indicated that the *Anopheles quadrimaculatus* index has not dropped substantially in the past decade. At several of the reservoirs adult counts of 500 to 1,000 per resting station have not been uncommon. With this plethora of vectors, a resurgence of malaria is an ever present possibility. In certain of our cities *Aedes aegypti* is prevalent. We have recently been identifying specimens from Dallas and Laredo. This species was found to be breeding in 12 percent of the premises inspected in San Antonio and 9 percent in Houston during a 1952 urban mosquito survey made by entomologists of the Communicable Disease Center and Texas State Department of Health.

Interest in mosquito control in West Texas has been greatly stimulated in recent years by increased mosquito annoyance and the occurrence of a considerable number of cases of arthropod-borne en-

* Deceased.

cephalitis in both human beings and horses. The population expansion in this area has been tremendous, effected chiefly by the spectacular spread of irrigation agriculture. The increase in encephalitis cases is undoubtedly a real one, although in part a reflection of improved ability on the part of the medical profession to differentiate the neurotropic virus diseases.

In Texas extensive utilization of oxidation ponds for the secondary treatment of sewage is an important factor in the production of encephalitis vectors, *Culex tarsalis* and *C. quinquefasciatus*. In consideration of the limited amount of time available to this discussion of Texas mosquito problems from a species standpoint it is felt that our principal attention should be centered on a survey now being made of the mosquito breeding propensities of these ponds.

Smallhorst, *et al.* (1953) define sewage oxidation ponds as those ponds of regular and controlled shape, depth and marginal area which have been specifically designed and constructed as waste treatment devices. Sewage lagoons are simply natural depressions, dry creeks or dammed ravines in which sewage is allowed to accumulate. Both ponds and lagoons are capable of producing satisfactory results but the present trend is toward the construction of oxidation ponds because they present less difficulty in controlling objectionable odors, weeds, and mosquitoes. Holding ponds are not intended to provide treatment for sewage as are the oxidation ponds or lagoons, but function simply as storage for the effluent during peak flows until it can be utilized in irrigation practices.

The reduction of the organic matter of sewage in these ponds by aerobic bacteria and algae has proven effective, economically feasible, and in accordance with the basic objective of water conservation. Consequently, their utilization by municipalities for treatment of both sewage and industrial wastes has been increasing tremendously, particularly since World War II.

There is as yet no general agreement

as to the proper shape and size of these oxidation ponds. It is agreed that to discourage non-aquatic vegetation the depth should be maintained at 2.5 to 3 feet. Since oxygen production by algae is directly dependent upon sunlight penetration there is little to be gained by having the water over 3 or 4 feet deep. The interior dike banks are usually constructed as steeply as possible to minimize marginal shallow water.

The development of oxidation ponds or sewage lagoons in Texas has been primarily concerned with the holding of the water for irrigation. The earliest of these installations appears to have been in San Antonio. This city passed an ordinance in 1901 authorizing the construction of a ditch, dam, and reservoir on Mitchell Lake for the proper disposal of its sewage. About 1925 Abilene, Texas, began using a series of oxidation ponds for the secondary treatment of sewage and to hold the effluent for the irrigation of city farm lands. In 1929-30 an experimental oxidation pond was constructed at College Station by Texas A. & M. College; results were so satisfactory that a 14-acre oxidation lake was built in 1933. There are now well over 200 cities in Texas utilizing these oxidation ponds for secondary treatment of sewage and the number is increasing rapidly.

The sewage oxidation ponds of 37 cities have been surveyed for mosquito breeding since June, 1953. Mosquito larvae were discovered in 23, or 62 percent, of these systems, 9 with only *Culex quinquefasciatus*, 6 with only *C. tarsalis* and 8 with both species. Other *Culex* taken from the ponds included a single collection each of *salinarius* and *thriambus*. Inspections were made during all seasons of the year and breeding was demonstrated during both winter and summer. Particularly in the southern half of the state the cold is seldom severe enough to do other than lengthen larval developmental periods.

The magnitude of the mosquito problem presented by the oxidation ponds surveyed has been directly proportional to the effectiveness of the management of grass and

other plants on the banks and in the ponds. To prevent erosion newly constructed soil banks are usually sodded with Bermuda grass. Unless this grass is mowed short it will hang over into the water and provide a favorable refuge for mosquito larvae. Elimination of the various types of emergent aquatic vegetation from the body of the ponds has not been observed to be much of a problem. Unless good vegetation management practices were in effect at the oxidation ponds which have been inspected, heavy mosquito breeding has almost invariably been found.

Mosquitoes actually breeding in the oxidation ponds constitute but a part of the over-all problem. During our survey extensive larval development has also been noted in close association with the ponds in such areas as ditches or potholes fed with seepage from the ponds. Often depressions have been created by shoveling out the dirt to build the pond dikes. These became hazards when filled with rain or seepage water. In the 37 cities surveyed mosquito breeding adjacent to the oxidation ponds was seen in 12 cases. *Culex tarsalis* and *C. quinquefasciatus* were the common mosquitoes but the collections also included several species of *Aedes* and *Psorophora*. In a single instance *Anopheles punctipennis* was taken.

The oxidation ponds may also be of im-

portance in the production of *Culex* and a variety of other mosquitoes as a result of effluent disposal. At 17 of the 37 cities surveyed, mosquito breeding was resulting from improper handling of effluent irrigation water or in creeks receiving the effluent. *Culex tarsalis* and *C. quinquefasciatus* were the usual mosquitoes taken although *Aedes*, *Psorophora* and occasionally *Anopheles* were also being produced in quantity.

In summary, well over half of the oxidation ponds being utilized by municipalities for secondary sewage treatment which we have surveyed have been breeding *Culex tarsalis* and/or *quinquefasciatus* either in the ponds, in adjacent seepage water, or in the effluent from the ponds. The production of encephalitis vectors threatens seriously to impair the usefulness of this valuable development in sewage treatment. However, it is felt that this problem can be alleviated by training the sewage plant operators in basic mosquito control techniques. In adequately designed oxidation ponds mosquito control is largely a matter of proper vegetation management and should require minimal use of insecticides.

Reference

SMALLHORST, D. F., WALTON, B. F. and MEYERS, JACK. 1953. The use of oxidation ponds in sewage treatment. Read before Engr. Sect., APHA meeting, No. 10, 1953.

DESPLAINES VALLEY MOSQUITO ABATEMENT DISTRICT

8130 Ogden Avenue, Lyons, Illinois

Member of American Mosquito Control Association

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The District was created under state law adopted in 1927 by the General Assembly of Illinois. The District has functioned for twenty-nine years.

THE NEED FOR STANDARDIZATION IN MOSQUITO CONTROL OPERATIONS

CHARLES F. SCHEEL

Vice-President, Des-Plaines Valley Mosquito Abatement District

Productive industry now quite generally recognizes standardization as fundamental, and that without it, mass production, and our high standard of living, would be impossible. This attitude has come about gradually, and has been brought about largely through research. For industrial research alone, this country now spends more than twice as much as it did in 1940, and with the further application of the newer technologies, is going on to spend even more. In this development standardization becomes even more important.

According to Benjamin Melnitsky, "Standards are practicable, profit-provoking solutions to recurring problems. Established tentatively, they are couched in objective terms and are based on the consent of those affected. They facilitate and often promote general usage of the best thoughts and practices on the subject being standardized."

Through standards, wasteful duplication, contradiction, and overlapping of effort can be avoided. In the case of research which leads to production, it is obvious that standardization is necessary not only in materials but in scientific method. The frugal use of time, material, and mental effort in a scientific research problem at least implies a certain set of standards, and adherence thereto.

Refer, for example, to the literature on yellow fever as a starting point; here was a problem which for its solution called for knowledge not then possessed. All resources, from the use of earth-moving equipment to the delicate techniques of the medical scientists, were brought to bear on the problem, each group using standards within its own field. In fact, little progress would have been made, had there not been standardized procedures in use for each phase of the work.

In the same way progress in vector control in other fields is accomplished. Nevertheless, one can find everywhere evidence that full advantage is not being taken of standardized procedures for certain operations—procedures that have been worked out in one district, which might well be more widely adopted. If we would only familiarize ourselves with available practical knowledge and experience in the operating field, and take more advantage of each other's hard-earned experience, we might be amazed at the cost reduction possibilities. The plea is made for a more uniform approach to the common problems, although it is recognized, of course, that variability must be taken into consideration in establishing a standardized abatement routine.

Equipment manufacturers, among others, have divergent views as to what may constitute proper machine treatment for a common field problem. Where the operating unit has the facilities and the skills to make a choice, this can be an advantage. At other times this diversity can become expensive, and a definite handicap. Lack of standardization in operating instructions accompanying equipment can also be frustrating and time-wasting.

Considering a common problem, in fogging for mosquito control, there are just about as many ideas and procedures in operation as there are fog machines. Questions such as when to employ wet or dry fogs, and the dosage to be used all cause delays because standard procedures either are not available or have not been adopted. Dosages of DDT vary from 0.1 lb. to several pounds per acre, under much the same conditions but in different areas, and the formulations may range from 1½ percent to 8 percent or more of toxic ingredient.

If not due to strictly local reasons the variations may be due to variations in the toxicity or other characters of the basic materials, which, if true should, in turn, be scrutinized. In the Middle West, a study of a certain group of competitive bids revealed a considerable spread of fillers, insolubles and impurities in samples submitted. In this analysis it was noticed, surprisingly, that next to the highest bidder was the best buy, where the net over-all price differential was as much as four cents a pound.

Easily interpreted standardized specifications, where they are missing, for raw material and other items used on either a critical or volume basis in our business, with recommendations for simple testing routines, are most certainly worthy of study. The question of when to use a dry or wet fog is not answered to everyone's satisfaction, possibly because various opinions on acceptable micron size and volume release have never been properly reconciled. This entire area of the use, type and quality of basic materials employed in abatement practices is unquestionably a fertile field for cost reduction through standardization.

There must be among our operating people enough experience accumulated over the years which, if laid out on the table, carefully studied and talked through, would eliminate many of these operating variables and effect some handsome economies. Such studies could reasonably be expected to open the way to the establishment of working tables covering optimum rates of application, selection of type and speed of equipment and a determination of the kind and density of material necessary to produce the best results with a given set of variables.

Another phase of our activity which should be scrutinized because of a lack of standardization, is the means employed to determine the scope of our problem and the effectiveness of our control efforts. There seems to be quite a diversity in the approach to this very important facet of our business. In general, there appear to

be three broadly used means for obtaining this information, namely: the mechanical method employing the use of slides, traps or other such devices; biological arrangements where landing and biting rates are observed; and the land and water survey procedure. No doubt each of these approaches or the desirable portions of each should form the basis of a consensus on how best to recognize the breadth of the problem before us and how to intelligently present the results and changes necessary to improve control measures. In this connection we have learned of instances where no effort whatsoever along this line is employed in the district to determine results. Here too much assurance of successful operation is based upon casual observation and on the complaints of the surrounding public, who have been conditioned to feel that two or three bites of an evening are sufficient indication of poor control. Often no data are at hand to refute such complaints, although it may be known by the district supervisor that pests have been reduced to below the annoyance level and that his fogging operations are successfully fulfilling their purpose. Conceivably much embarrassment can ensue under such circumstances. Just before leaving home for this convention, we were shown a copy of a survey and study of the mosquito measurement program conducted by a special committee of the California Association under the chairmanship of Mr. Theodore Aarons. It appears that the main purpose of this group was to review the relative effectiveness and economics of various methods in use throughout the state for measuring adult and larval mosquito population. Their intention, obviously, is to modify or correct significant parts in the program which would lead to the development of a set of recommendations to be acted upon by the board of directors of the California association. This seems like significant progress in a recognition of unwarranted diversification in practices. The study will surely lead to at least a state-wide acceptance of standardization in determin-

ing mosquito population densities and a degree of uniformity in appraising the effectiveness of their control practices.

We have large areas, state areas if you will, in which the overall issues of variables may be somewhat dissimilar between two sections, but are essentially the same within a given section. All areas have fogging or misting programs of some sort and use specific methods in appraising their effectiveness. If as a starter we do nothing more in an approach toward standardization than to rationalize our fogging, larviciding and testing procedures in sections where problem characteristics are known to be pretty much the same, and at the same time take full advantage of any available material on standardization as applied to control, the results would unquestionably be quite revealing. We have the scientific data, the field experience and a national organization which is making every effort to provide the necessary additional knowledge, impetus and inspiration to place our activities on a continuing sound operating basis, and we should take fuller advantage of these outstanding facilities.

In closing, liberty is being taken to quote a few paragraphs from a paper presented by Don M. Rees at the 20th annual conference of the California Mosquito Control Association in 1952, which seem to be pertinent to this paper: "There is no cure-all that will assure effective mosquito control. I have come to the conclusion that we will all too frequently become self-satisfied with our own method of operating our own local mosquito control program and if not disturbed we continue year after year with little change. When representatives from local districts attend meetings such as this and those arranged by the American Association they frequently learn that they are not obtaining effective results which are possible through the adoption of approved methods which are being used in other districts.

"In my humble opinion, mosquito control is a service that, through public demand, will not only remain but will be extended until all major centers of popula-

tion in the Americas, where a mosquito problem exists, will eventually have a mosquito control program.

"I am also convinced that this public service of mosquito control can be most effectively, efficiently and economically conducted on a local level through the guidance and unification of a non-profit, non-political, strong parent organization such as the American Association.

"I am further of the opinion that without such a strong organization, mosquito abatement work will gradually be taken over by other local or federal governmental agencies at greater cost to the public and with less effective mosquito control results. The American Association invites all workers and agencies interested in the program to participate in this organization dedicated to more effective mosquito control.

"I am confident if we do not all co-operate, and assume the responsibility of directing and improving the mosquito control program through the American Association, we will unquestionably be taken over by some other agency, and the program directed for us."

Dr. Rees's remarks are surely to the point and need no embellishing. We should be our own severest critics rather than unnecessarily expose ourselves to the wrath and whims of any outside agency. Aside from the personal pride and satisfaction one should always derive from his individual accomplishments and their potential contribution to the health and comfort of mankind, let us never lose sight of what we owe to the public that supports our entire effort. The public reserves the prerogative and often assumes the role of challenging any procedure in our activity which appears to be costly and ineffective. His convictions may not always be supported by actual fact, but remember that there is no tougher task-master than an aroused tax-payer; one should always be prepared to meet intelligently his or any other challenge to our efforts.

Among the many possibilities of realizing this end, there is no more effective

approach than that of an enlightened collaboration of diversified views and practices, shaken down to uniform, economical and realistic application.

The medium of standardization is here-with humbly submitted as offering the greatest potentialities for this accomplishment.

MOSQUITO CONTROL TRAINING ACTIVITIES OF THE COMMUNICABLE DISEASE CENTER

HARRY D. PRATT

Department of Health, Education, and Welfare
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The mosquito control training activities of the Communicable Disease Center may be divided into three main categories: (1) scheduled courses in Atlanta or its field stations, (2) decentralized courses held in the states at the request of State Health Departments or the mosquito control or abatement associations, and (3) the production and distribution of training aids.

SCHEDULED COURSES. The Communicable Disease Center offers scheduled, one- and two-week courses in mosquito and insect control in Atlanta several times a year, and at the field stations or at various locations throughout the country through Field Training Stations located at Amherst, Massachusetts; Mt. Vernon, New York; Pittsburgh, Pennsylvania; Oklahoma City, Oklahoma; Denver, Colorado; and Seattle, Washington. The scheduled courses to be given at Atlanta for the fiscal year July 1, 1956 to June 30, 1957 are listed below:

Insect and Rodent Control, July 16-27, 1956

Insect Control, September 17-28, 1956

Mosquito Control, November 5-9, 1956

Biology and Identification of Arthropods of Public Health Importance, December 10-21, 1956

Insect Control, April 1-12, 1957

Insect and Rodent Control, May 13-24, 1957

The curriculum for each of these courses varies to meet the individual needs of students but always contains at least the following elements:

- Mosquito-borne diseases
- Biology of mosquitoes
- Identification of mosquitoes
- Insecticides
- Equipment
- Temporary control measures
- Permanent control measures

In considering these elements in our courses, it is worth calling attention to the unusual opportunities available at the Communicable Disease Center for keeping informed on recent developments in each of these fields. For example, in the field of mosquito-borne diseases, any major development is usually called to our attention when a State Health Officer makes a request for assistance to the Communicable Disease Center—as in the outbreak of encephalitis in California in 1952, in Texas in 1954, or in Indiana or Kentucky in 1955, or the small outbreak of malaria due to a Korean veteran in California in 1952. We, therefore, have early notice of interesting developments in the field of epidemiology and frequently learn the results of investigations sometimes months or even a year or more before such reports are published.

In the portion of our courses dealing

with identification of mosquitoes, we are able to make full use of filmstrips and pictorial keys developed at the Center and to utilize the extensive insect collection containing almost all of the North American species of mosquitoes. Therefore, we are able to "tailor" the laboratories to the individual needs of each student. Thus, men from western United States receive special attention on such important species as *Culex tarsalis*, *Aedes dorsalis*, or *Aedes nigromaculis*, while people from East Coast areas study such salt-marsh mosquitoes as *Aedes sollicitans*, *Aedes taeniorhynchus*, or *Aedes cantator*.

In the portion of our courses dealing with the biology of mosquitoes, insecticides, and applied control measures, we are able to draw extensively on current studies conducted by the Center at Savannah, Georgia, or at field stations throughout the United States. Also, we give our students opportunities to "learn by doing." They participate in field trips to collect specimens, work with late model pieces of control equipment such as the fog and mist machines, or conduct actual practice in mist larviciding or residual spraying.

In addition to these courses, pertaining to vector control, a more advanced course, the "Biology and Identification of Arthropods of Public Health Importance," is scheduled once a year. During this course, three days are devoted to lectures or laboratory sessions on mosquito biology and identification and on the present status of mosquito-borne diseases in this country. A number of students from mosquito control projects have attended this course, listening to the lectures on many varied aspects of medical entomology but devoting all laboratory periods to the study of mosquitoes. Other students in this course have studied flies, fleas, lice, ticks, cockroaches and other arthropods of public health importance, according to their own need and interest.

Frequently, after students have taken these scheduled courses in Atlanta or at one of the Field Training Stations, ar-

rangements have been made for students wishing additional field experience or specialized instruction in biology, toxicology, chemistry, or equipment to study these subjects at the Technical Development Laboratories in Savannah, Georgia, or at field stations at Newton, Georgia; Logan, Utah; Milk River, Montana; Angostura, South Dakota, or Bakersfield, California. Two other installations of the Communicable Disease Center which mosquito control people frequently visit are the Virus and Rickettsia Laboratory at Montgomery, Alabama, or the Greeley, Colorado field station. Studies on many phases of encephalitis have been conducted at these two stations for a number of years.

During calendar years 1954 and 1955, some 330 students from 38 states have come to Atlanta to study vector control. Another 300 additional students received similar training in decentralized courses in their home states.

DECENTRALIZED COURSES. In conjunction with the various State Health Departments and the Field Training Stations of the Center, the following four decentralized courses in mosquito control were offered during February and March 1956: a five-day course in Utah from February 21-25; a three-day course in Oregon from February 28-March 1; a two-day course at the University of Rhode Island on March 22 and 23, and another two-day course at the University of Massachusetts on March 26 and 27. These courses are adaptations of the basic courses offered in Atlanta, with specific reference to the species involved in each area, local conditions and organizations. In Oregon, for example, the special problems created by irrigated pastures and log ponds provide the central theme. In Rhode Island and Massachusetts salt-marsh mosquito ditching and pre-hatch treatment for inland single-brooded, early *Aedes* species are emphasized. The Communicable Disease Center is ready to assist in training courses of these types, by providing lecturers, literature, or training aids, insofar as personnel, travel funds, and schedules permit.

TRAINING AIDS. The third major way in which the Communicable Disease Center assists in training in connection with mosquito control is in the production and distribution of training aids. Ever since the beginning of our organization as the Malaria Control in War Areas program, our Center has been involved in the production of pictorial keys, specialized literature, series of black and white or colored slides, filmstrips, and motion pictures. At the present time there are available six pictorial keys dealing with mosquitoes:

Pictorial Key to Adult Female Anophelines of U. S.

Pictorial Key to Anopheline Larvae of the U. S.

Pictorial Key to U. S. Genera of Female Mosquitoes

Pictorial Key to Some Common Female Mosquitoes of the United States

Pictorial Key to U. S. Genera of Mosquito Larvae

Anophelines—Culicines

Reasonable numbers of these pictorial keys have been distributed free of charge to many colleges and universities, mosquito abatement districts, and health departments.

The Center has produced a series of filmstrips and motion pictures which are available on short-term loan, or which may be purchased from United World Films. A list of some of these films and filmstrips has been distributed to you. With these training aids: pictorial keys, slides, filmstrips, or motion pictures, it is possible for any mosquito control agency to organize its own training program,

utilizing only personnel from within its own organization.

In these days of "do it yourself" handymen, such training aids in the hands of local personnel often contribute to a successful training conference. We know that there is no substitute for a person with actual experience in mosquito control. We also are firmly convinced that audio-visual aids have their place in most training sessions. They serve as an introduction or summary of a particular subject, provide specific information, or allow a change of pace.

The March issue of the magazine "Pest Control" contains an annual report by our Technical Development Laboratory on public health pesticides. A helpful summary gives the latest methods of controlling mosquitoes and other insects and rodents of public health importance. The Technical Development Laboratory also issues each year its "Operational Memoranda" and "Clinical Memoranda" on economic poisons. These may be obtained by writing to the Chief, Technical Development Laboratory, P. O. Box 769, Savannah, Ga.

In closing, I wish to state that the Communicable Disease Center wishes to work in close cooperation with mosquito control agencies. We shall be glad to have people from your organizations attend classes in Atlanta or at our field stations. Also we will assist in conducting decentralized courses in the states or with individual courses held by your own organizations. These services and training aids are available to you by writing to the Chief, Communicable Disease Center, 50 Seventh Street, N. E., Atlanta 23, Georgia.

Aedes Stenei, A NEW SPECIES OF MOSQUITO FROM JAMAICA, B.W.I., WITH REDESCRIPTION OF A CLOSELY RELATED SPECIES (DIPTERA, CULICIDAE)

GEORGE A. THOMPSON, JR.

A new species, *Aedes* (*Howardina*) *stenei* is described. *Aedes* (*Howardina*) *inaequalis* (Grabham) is proposed as the correct name for *Aedes aureostriata* (Grabham) and the species is redescribed.

ACKNOWLEDGMENT

The author wishes to express his appreciation for the tireless efforts of Dr. H. D. Pratt, and for the assistance and encouragement of Dr. G. H. Bradley, Mr. M. H. Goodwin, Jr., Mr. W. H. W. Komp, and Dr. Alan Stone. The drawings were made by Mr. C. J. Stojanovich, scientific illustrator, at the Communicable Disease Center, Atlanta, Ga.

Aedes (*Howardina*) *stenei* NEW SPECIES

Aedes aurites Hill and Hill, Mosq. Jam., Inst. Jam., 42, 1948 (in part) *Aedes n. sp.*, G. A. Thompson, Mosquito News, 7(2):78, 1947.

FEMALE: *Proboscis* moderate, slender, black. *Palpi* dark brown; extremity of terminal segment tipped with silvery to pale golden scales; about as long as the basal 3 segments of the antennae. *Antennae* dark, almost as long as the proboscis. *Clypeus* dark. *Occiput* with a median row of narrow, flattened, golden scales; the row bordered by a wider row of wide, black scales on either side; wide, light golden scales laterally except for black ones behind each eye; erect forked, black scales on the nape; mixed black and yellow, long bristles hanging between the eyes.

Prothoracic lobes with silver scales and black bristles. *Mesonotum* brown; a submedian pair of lines of small, golden scales extending from the anterior margin to just anterior to the antescutellar space, a mediolateral golden pair arising from

near the anterior margin and extending posteriorly along the lateral margins of the antescutellar space and terminating on the lateral lobes of the scutellum, the lateral pair, also golden, arise near the mid-point of the anterior margin and extend along the lateral margins to about the insertion of the wings, sometimes the submedian and mediolateral pairs connect at the anterior margin with the laterals; the lateral lines become indistinct at about the insertion of the wings and may or may not extend posteriorly to join the mediolaterals on the lateral lobes of the scutellum; the golden median line arises at about the anterior margin of the antescutellar space and extends posteriorly, ending on the median lobe of the scutellum. The golden lines are separated by lines of blackish scales, which are similar to the golden scales but larger. Several long, black bristles arise on the thorax, a few black bristles arise along the lateral margins and many above the insertion of the wings. The golden lines are not as wide as the dark ones. A small patch of golden scales is located on the anterior promontory, between the submedian lines. *Scutellum* brown; the center lobe with a median line of narrow, golden scales bordered by a row of wider black scales on either side, long bristles arise from the posterior margin of the lobe; the lateral lobes are golden scaled and bear long bristles. *Pleurae* with six patches of silver scales as follows: on the propleuron, just before the prealar setae on the pleura, the upper sterno-pleuron, lower sterno-pleuron, above the coxa of the mid-leg, and on the middle of the mesepimeron. The pleuron always bears black bristles. *Wings* with narrow, dark scales having violaceous reflections, the veins of the costal margin and vein Cu₂ are more

densely scaled than the other veins. *Halteres* with a light stem, the lower hemisphere of the lobe with some dark scales, the upper hemisphere light.

Abdomen dark; scales violaceous to velvety black; segments 2, 3, 4, and 5 with basal bands of pale scales, somewhat golden in some lights; segment 6 with a pale golden, central, basal patch; the first 5 or 6 segments have triangular patches of silver scales at the anterior lateral corners. *Venter* pale scaled; scales mostly with pale golden reflections, the two or three posterior segments may have some dark scales apically. *Fore leg*: Femur dark scaled above, violaceous; light scaled below. Tibia dark, violaceous above with a few white scales toward the apex. Tarsal segments all dark; claws simple. *Mid-leg*: Femur as above. Tibia as above, Tarsal segment I with a basal white band, which is often incomplete, segment II with a small white spot which may be obsolete, the remaining segments all dark. *Hind leg*: Femur and tibia as above. Tarsal segments, I, II, and III with basal white rings, the ring on segment III distinct segments IV and V all dark.

Male: *Coloration* as in the female. *Palpi* black, violaceous; slightly longer than the proboscis. *Antennae* dark; between $\frac{1}{2}$ and $\frac{2}{3}$ the length of the proboscis.

Genitalia: The terminalia of the holotype are mounted and slide 450902/1 is deposited with the U. S. National Museum. Paratype 460101/26 is also with the U. S. N. M. Paratypes 451002/8 and 460101/23 are deposited with the Communicable Disease Center, U. S. Public Health Service, Atlanta, Ga.

Side piece about $2\frac{1}{2}$ times as long as basal width, sides subparallel; basal lobe small, conical, about $\frac{1}{4}$ up the side piece, and bearing a strong spine at the tip which reaches almost $\frac{3}{4}$ the length of the side piece. *Clasper* slender, swollen at base, about $\frac{2}{3}$ the length of the side piece, terminal spine stout, about $\frac{1}{4}$ the length of the clasper. *10th Sternites* large, slightly thickened at the tips. *9th Tergite* lobes moderate, usually with 2 stout spines.

LARVA, 4TH INSTAR: (Fig. 1 and 2) *Head* wider than long. Antennae transparent; very slightly curved inward; slightly tapering to a blunt apex; the apex with 4 spines of unequal length and a flat process; antennal hair single, moderately stout, not $\frac{1}{2}$ as long as the shaft, arising about midway of the shaft; surface of the shaft with spicules. *Preclypeus* with a pair of stout, single, curved spines. *Mentum* a wide angle with 8 to 11 blunt teeth on either side of the central tooth. *Head Hairs*: Upper head hair several-branched, longer than the lowers, 3-4- or 5-branched is common for the species. Lower hairs multiple branched, of moderate length, 10-15-branched tufts are common. Antennal tuft 4-5- or 6-branched, as long as the lower head hairs. Sutural hair single, long. Trans-sutural hair 3-branched. Supraorbital hair single, long. Postclypeal hair 3- or 4-branched, very long, visible at 100X. *Thorax* and *Abdomen* with large stellate hair tufts; lateral abdominal hairs of segments I and II triple, the remainder single; integument smooth; anterior thoracic hair tufts as follows: tuft I, 9-branched; II, 1-branch; III, 12-branched; IV, 1-branch; V, 2-branched; VI, 1-branched; VII, 2-branched. Tufts V, VI, and VII arise from a common plate: hairs of tufts I, II, and III have split tips and also small spinules along the shaft. Comb usually of 18 straight, stout spines in a curved row; each spine is fringed toward the tip; each spine is about the same width from the base to the blunt, tapering tip. *Airtube* about 5-6-times the length of the basal width; not swollen; tapering gradually. *Pecten* of simple, elongate spines; 15 to 23 in each row, extending to almost midway of the tube; a pair of tufts, double and finely feathered, are located beyond the middle of the tube. *Chitinous plate* of anal segment saddle-shaped, widely open below. *Anal segment* with two full and a partial third row of spines on the posterior margin; spines of the first row (apical) widening to about the middle and then tapering to a point, feathered

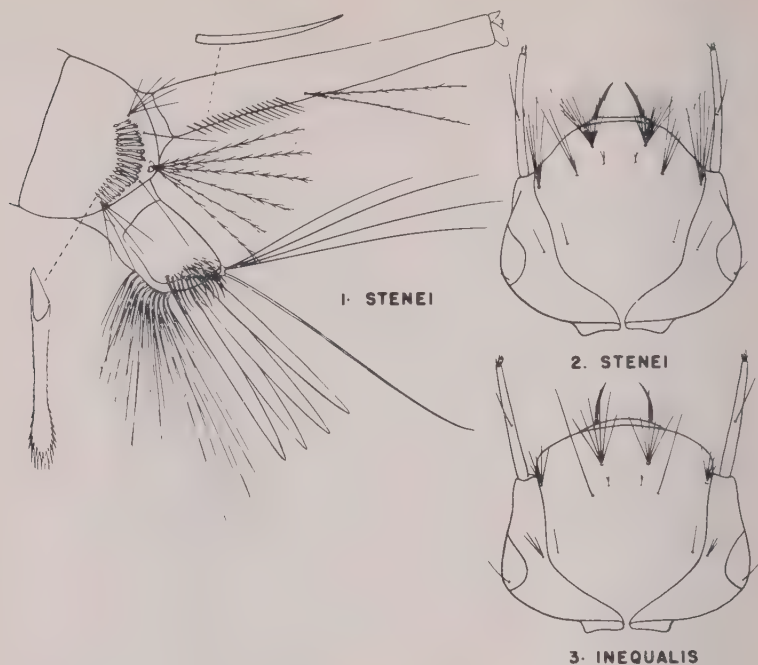


FIG. 1. Caudal segments of 4th instar larva of *Aedes (Howardina) stenei*.

FIG. 2. Head of 4th instar larva of *Aedes (Howardina) stenei*.

FIG. 3. Head of *Aedes (Howardina) inaequalis*.

from middle to tip; a single, long, stout hair bearing spicules terminates the row of spines on each side, ventrally; the other spines are simple and taper from base to tip. *Ventral brush* well developed. *Dorsal brush* a long, single hair and a 7-branched hair about $\frac{1}{2}$ the length of the single one, on each side. *Anal gills* long and slender, longer than the anal segment.

HOLOTYPE-MALE. The larva from which the adult was reared was collected from tree-borne bromeliads. The collection was made near Hope Farm, Clarendon Parish, Jamaica, B.W.I., just above Porus, on the road to Mandeville, September, 1945, by the author. The locality is about 1,000 feet above sea level. The holotype and associated larval skin bear the collection number 450902/1 and are deposited with the U. S. National Museum.

ALLOTYPE-FEMALE. The collection data are the same as for the holotype. The allotype and larval skin are in the U. S. National Museum collection, numbered 450902/2.

PARATYPE-MALE. Collected at the type locality. Specimens numbered 451002/3, 460101/15, 460101/20, 460101/25, 460101/26 and 460101/30 are deposited with the U. S. National Museum. Specimens numbered 451002/8, 460101/23 and 460101/28 are in the collection of the Communicable Disease Center, Atlanta, Ga.

PARATYPE-FEMALE. Same locality as holotype. Specimens numbered 451002/2, 451002/10, 451002/13, 460101/18 and 460101/27 are deposited with the U. S. National Museum. Specimens numbered 460101/29 and 460105/4 are with the

Communicable Disease Center, Atlanta, Ga.

The larvae of the species were found only in bromeliads, more commonly above an elevation of 1,000 feet. The larvae of *stenei* and *inaequalis* occur together, often in great numbers. All collections from which these studies were conducted were made in Clarendon Parish, Jamaica, B.W.I. The majority of the specimens were taken in a heavily wooded area, near Hope Farm, just above Porus on the road to Mandeville. Both species were taken at will from September, 1945, to January, 1946.

The adults are fierce biters, readily attacking in the day, especially in the shade of the bromeliad-laden trees. Adults were also taken in light traps located several miles from the mountains. It is possible that the species may breed in the bromeliads found at low elevations, although such breeding was not observed. It is quite probable that the *Aedes aurites* of Hill and Hill represents *Aedes stenei* and *inaequalis* of this paper, hence the citation *Aedes aurites* Hill and Hill, Mosq. Jam., 42, 1948 (in part).

The species is named for Professor Andrew E. Stene, for many years State Entomologist of Rhode Island.

Aedes (Howardina) inaequalis (GRAHAM)

Howardina aureostriata Grabham, (not (*Culex*) *Aedes aureostriata* Doleschal, 1857, nor *aurostriata* Banks, 1906) Can. Ent. XXXVIII, 171, 1906

Howardina inaequalis Grabham Can. Ent. XXXIX, 25, 1907 (Mailed January 12, 1907)

Aedes inaequalis (Grabham) Mosq. News 7(2):78, 1947

Dr. Grabham described the species in 1906 as *Howardina aureostriata*. Later (Howard, Dyar and Knab) it was shown that *Howardina* was a synonym of *Aedes*, and with the change in generic name, the specific name, *aureostriata*, was found to be preoccupied by a species originally described in the genus *Culex* but later changed to the genus *Aedes*. In 1907,

Theobald had described material sent to him by Dr. Grabham. Hence, when *aureostriata* was shown to be preoccupied, the species was called *aurites* Theobald. However, in 1907, Dr. Grabham described *Howardina inaequalis* and publication of this work appeared 42 days prior to Theobald's description of *aurites*.

The original description of *aureostriata* by Grabham is comparatively complete for all stages. An important omission was that the larval head hairs were not enumerated. The original description of *aurites* by Theobald was based on but two females that were sent to him by Dr. Grabham. Sometime between 1910 and 1915 when, at Dyar's request, Busck examined the type material, he reported it as "in rather bad condition." The original description of *inaequalis* by Grabham is, in general, a comparison of characters with those of *aureostriata*. The larval head hairs as enumerated in the comparison of *inaequalis* and *aureostriata* fall within the range observed by the author during his rearing studies. The evidence leaves little doubt of the fact that *aureostriata*, *aurites* and *inaequalis* are synonyms.

Since 1911 various authors have given priority to either *aurites* or *aureostriata*, but have neglected to consider *inaequalis*. However, as *aureostriata* is preoccupied, the choice lies between *inaequalis* and *aurites*. The original description of *Howardina aurites* Theobald, appears in his Mon. Culic., IV, 1907 which, the records of the British Museum (Natural History) show, was published on February 23, 1909 (correspondence N. D. Riley, Keeper, Dates April 4, 1946). The original description of *Howardina inaequalis* Grabham appears in Can. Ent. XXXIX, 1907 and the issue carries the note "Mailed January 12, 1907." In view of these facts, *inaequalis* is indicated as the correct specific name.

ADULT FEMALE: Topotypes 450708/2, 450708/9, 450708/11, 450801/8, 451001/1, 451001/6, 451001/14, 460101/4 and 460101/12 are deposited with the U. S. National Museum. Topotypes 460101/14

and 460101/16 are in the Communicable Disease Center collection, Atlanta, Ga.

Generally as in *stenci* with the following exception: *Occiput* with black and yellow scales on the nape. *Mesonotum* with golden lines at least as wide as the black ones. *Mid-Leg*: Tibia without apical white spot. Tarsal segment I with a narrow, dorsal, basal white spot, segments II, III, IV and V all dark. *Hind Leg*: Tarsal segment I and II with narrow, basal white bands, III with an indefinite white band which is something obsolete, IV and V entirely dark.

ADULT MALE: Topotypes 450801/5 and 451001/9 are deposited with the U. S. National Museum. Topotypes 460101/11 and 460101/17 are with the Communicable Disease Center collection.

Coloration as in the female. *Palpi* black; violaceous reflections, especially on the terminal segment; slightly longer than the proboscis, a very narrow white ring may appear at the apex of the first segment. *Antennae* dark; between $\frac{1}{2}$ and $\frac{2}{3}$ the length of the proboscis.

Genitalia: The mounted terminalia of topotype male 450801/5 and other terminalia 45078/7 are deposited with the U. S. National Museum. Terminalia 450708/12 and 450801/7 are with the Communicable Disease Center collection at Atlanta, Georgia.

Side piece about twice as long as basal width, somewhat conical; basal lobe small, conical, about $\frac{1}{4}$ up the side piece, with a strong spine on the tip reaching almost $\frac{3}{4}$ the length of the side piece. *Clasper* slender, about $\frac{2}{3}$ the length of the side piece, with a stout terminal spine that is about $\frac{1}{4}$ the length of the clasper. *10th Sternites* large, thickened at the tip. *9th Tergite* lobes moderate, usually with 2 moderate, stout spines.

LARVA, 4TH INSTAR: (Fig. 3) The exuvium of each of the following topotypes is deposited with the U. S. National Museum: Females 450708/2, 450708/9, 450708/11, 450801/8, 451001/1, 451001/6, 451001/14, 460101/4, 460101/12; Males 450708/7, 450801/5, 450801/6 and 451001/9. The exuvium of each of the following has been deposited with the Communicable Disease Center, Atlanta, Georgia: Females 460101/14 and 460101/16; Males 450801/7, 460101/11 and 460101/17.

Generally as in *stenci* with the following exceptions: Antennal hair tuft a single, moderate stout hair. *Mentum* a wide angle with about 10-20 blunt teeth on either side of the central tooth. *Head Hairs*: Upper head hair single, long sometimes double. Lower head hair 6-branched, of moderate length; rarely more than 6-branches. Antennal tuft small, short, fine, 3-branched. Suture hair short, fine, single, or 2-branched. Transsuture hair long, triple. Post-clypeal tuft very short, 3-4-branched, not visible at 100 $\times$. *Abdomen* and *Thorax*: The anterior thoracic hair tufts are arranged as follows: I, 5-branched; VII, 1-branch. *Comb* usually of 16 stout, straight spines in a curved row; each spine is finely fringed toward the tip; spines with sides subparallel. *Pecten* of simple, elongate spines; about 15-18 in each row on the basal $\frac{1}{3}$ of the tube; a pair of tufts, double and finely feathered, inserted behind the middle of the tube. *Anal segment* with one row of long spines on the posterior margin preceded by 2-3 rows of strong setae; each spine widening to about the middle and then tapering to a point, feathered from middle to tip; a long stout hair bearing spicules terminates each row of spines ventrally.

INVESTIGATION OF THE BIOLOGY AND CONTROL OF MIDGES IN FLORIDA (DIPTERA: TENDIPEDIDAE)

A PROGRESS REPORT

D. B. LIEUX¹ AND J. A. MULRENNAN²

INTRODUCTION. During recent years, midges have become an increasingly serious problem in many sections of peninsular Florida. Since the adults do not bite, transmit disease, nor are they known to take food, it may be difficult to realize the extreme annoyance and economic loss caused by these insects without personal observation of their emergence, which frequently occurs in phenomenal numbers. While species of other genera are present in Polk County, the predominant one is *Glyptotendipes paripes*. Biological data, reported herein, pertain only to this species, unless otherwise indicated.

SUMMARY OF LIFE HISTORY DATA. **Oviposition.** Oviposition occurs principally at night, while the caged females are resting on the water's surface, for deposition of the egg masses. The number of eggs comprising a mass varies considerably. They are encapsulated in a gelatinous substance, which apparently serves as the initial food of the newly hatched larvae. Being heavier than water, the egg masses sink to the bottom, where hatching occurs in approximately two to seven days, depending on the temperature of the water.

Larvae. Following initial feeding within the gelatinous material, the very small larvae leave the mass and burrow into the lake or river bottom. The burrow is then lined with silk-like threads, secreted by the larva, to join together particles of sand or other bottom material to form a tube-like structure, open at both ends, through which the water is circulated by rapid undulatory movements.

The tubes are fashioned in a general "U" shape, only the tips protruding slightly above the lake bottom. Thus, the larvae live embedded in the lake bottom and are apparently provided a high degree of protection from fish predation.

FEEDING TECHNIQUE. A unique feeding technique is employed by the larvae, utilizing a net or filter of silk threads spun across the inside of the tube, which collects suspended food material carried into the tube by larval undulations. After forming the net, which requires only a matter of seconds, the larva reverses its direction within the tube and undulates its body for several minutes. Afterwards, the larva again turns around to consume the food retained by the net, which is then reconstructed for repetition of this routine. These undulating movements, which involve a considerable expenditure of energy, concurrently enhance oxygenation of the gills, through which oxygen is obtained directly from the water. Undulations and feeding are continuous except at low temperatures.

Bottom samples taken with an Ekman dredge indicate a marked heterogeneous larval population and all instars may be taken virtually throughout the year in heavily infested lakes. There is little uniformity in distribution of the larvae, which may be found in most areas of a lake. Bottom samples have yielded densities ranging up to 1436 larvae per square foot.

The duration of the larval stage may vary considerably, depending on conditions of food and temperature. In addition, some variation occurs between individuals which hatch simultaneously. Under favorable conditions, this stage may be completed in approximately three

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weeks or extended up to several months, under adverse conditions. Advanced instars are blood-red in color and attain a length of approximately three-quarters of an inch at maturity.

Larvae have been collected at depths ranging from less than one inch to more than thirty feet. This species is usually found in sand or a mixture of sand and other bottom material, although certain other species of *Tendipes* are most frequently taken in muck areas. Lakes in the study area are slightly alkaline and no significant difference in pH was noted between heavy and weak breeding lakes.

Reared larvae have been observed, on occasion, to feed outside the tubes, but apparently this is limited largely to situations where their food requirements are not being fully satisfied.

PUPAE. Transformation to the pupal stage occurs within the larval tube, and is usually completed within 72 hours at favorable temperatures. The pupae leave the tubes some hours prior to ascending to the surface, where the adults emerge and are almost immediately prepared to fly.

ADULTS. Regardless of which part of the lake emergence occurs, flight is generally with the wind and the adults evidence a strong attraction to most light sources. Following an emergence, the water or lee shore may be conspicuously covered with large numbers of pupal casts.

EMERGENCE. Emergence usually occurs at night and is most intense during the early part of the evening. During the colder months from about December through February, emergence is usually greatly minimized. Heavy emergence may result in a virtual blanketing of the down-wind shore, lawns, shrubs and structures near the shore, and illuminated buildings are especially attractive to the adults, which may enter through quite small openings.

MATING. Mating occurs principally, though not exclusively, during the night of emergence and the bulk of oviposition

is apparently accomplished during the second or third nights, after which the females die. During the day, adults are sedentary unless disturbed, resting rather quiescently on vegetation, structures and other surfaces.

LONGEVITY. Longevity of the adults is influenced by temperature. During the summer, adults live only a few days, which may be extended by low temperatures to approximately one week. While the adults are not known to feed, there are indications water may be consumed.

DESCRIPTION. The adults of *G. paripes* are dark with clear wings and although they have a mosquito-like appearance, they lack the proboscis and characteristic wing scales of 'mosquitoes'. Males are readily recognized by their plumose antennae. The body length of the females approximate one-quarter inch and the males about five-sixteenths inch in length. Adults of *Tendipes spp.* are somewhat larger. When disturbed or otherwise active, they emanate a distinct wing-beat "hum."

DISPERSAL. While extreme annoyance is usually confined to areas proximate to the shore, dispersal in relatively small and diminishing numbers may occur up to at least one mile from their source.

PREDATORS. Known predators of midges include fish, birds, certain predaceous insects and spiders. Many species of fish feed to some extent on the various forms of midges, when available to them. The principal limiting factor in midge predation by fish appears to be in the high degree of protection provided the larvae by their unique tube dwellings embedded in the lake bottom. Under conditions favorable for the development of midges in large numbers, it appears unlikely that fish alone can provide effective control.

FACTORS CONDUCTIVE TO MIDGE PRODUCTION. **LARVAL FOOD.** Of the nearly one hundred lakes in the Winter Haven area, some sixteen are inter-connected by canals navigable by small craft. These are referred to as the Chain-O-Lakes, encompassing over four thousand acres. The

vast majority of these lakes are heavy breeders of midges. Most other lakes in the area are "weak" or relatively non-breeders of these insects. The latter are generally clear and evidence a very low, or absence of, plankton turbidity. The critical difference between heavy and weak breeding lakes, under otherwise favorable conditions, appears to be in the fertility of the lake and quantity of larval food.

Dissection and examination of the intestinal tract contents of midge larvae indicated that the identifiable food material could be collectively termed plankton, principally algae and to some extent protozoa. The balance of the material was considered organic detritus.

In addition to natural organic matter present in, or that being washed into the lakes, other sources of nutrients, certain of which may be of much greater importance in the production of larval food, include domestic sewage either treated or untreated, organic industrial wastes from canneries, dairies, etc., leaching by rainfall of fertilizer following agricultural and domestic use, and herbiciding activities such as hyacinth control. From a standpoint of fish production, these insects can be considered beneficial and their presence in large numbers is indicative of a fertile and productive body of water.

CONTROL. Adulticiding techniques have provided temporary relief from adult annoyance in localized areas. Either thermally produced aerosols of a DDT-oil solution or BHC dusts have been used with varying degrees of success.

Periodic larviciding has been employed extensively in many lakes in Polk County since the spring of 1953. Only suspensions of wettable powders have been used, since this formulation, among other considerations, is deemed safer from standpoint of fish mortality. Application is accomplished from surface craft by introduction of the toxicant into the turbulent wake of the boat, while travelling in a pattern conducive to maximum distribution of the insecticide.

Initially, suspensions of benzene hexachloride at dosages ranging from approximately 0.16 to 0.20 lb. of gamma isomer per acre provided dramatic temporary control of midge immatures. However, considerable resistance was encountered in all lakes treated, within a period of several months. Thereafter, EPN at dosages of 0.1 to 0.125 lb. of active material per acre has been used periodically in some twenty-four lakes in the county since March of 1954. Each of these has been treated from at least once to as many as fourteen times with this chemical. During the spring of 1955, apparent resistance to EPN was encountered in two lakes most frequently treated with this chemical, eleven and thirteen times respectively. Doubling the usual dosage and a combination of BHC-EPN failed to provide satisfactory control. In addition to other tests, this supply of EPN was subsequently used to treat two other lakes, previously treated two and four times respectively with EPN, and apparent complete larval control was obtained. Subsequent laboratory comparisons utilizing larvae from treated and untreated lakes also indicated physiological resistance to EPN.

Thereafter, a considerable number of insecticides were tested including inorganics, chlorinated hydrocarbons, experimental and commercially available organic phosphorus compounds and certain botanicals. None of these was entirely satisfactory or there were contraindications for use under the conditions which existed from the standpoint of either mammalian toxicity or cost.

Other approaches currently being explored include the possible use, under certain conditions, of a weakly emulsified oil, possessing a specific gravity greater than water, which enables the oil to settle out on the lake bottom. Pollution control, when feasible, supplemented by algicidal treatments and subsequent heavy stocking with such desirable bottom-feeding fish as bluegill bream are also being explored.

Relatively large light-traps, equipped with a 20 watt fluorescent blacklight, have

provided an encouraging degree of protection to small areas. The principal limiting factor of this technique is accelerated wind velocity, the deterring effects of which can be minimized by judicious location of the traps.

ACKNOWLEDGMENTS. Grateful acknowl-

edgment is made to R. O. Hayes and officials of the CDC, Public Health Service Laboratory, Savannah, Ga. for their kind assistance in the larval food identifications and to personnel of the Polk County Mosquito Control Program for assistance in conducting some of the field tests.

AIR AND INSECT PENETRATION OF INSECT SCREENS

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One phase of the research work done by the Sanitary Engineering Branch of the Engineer Research and Development Laboratories at Fort Belvoir on insect screens has been to determine the amount of air blocked from passage by screens of different mesh sizes. The objective of this work was to find screens which would be of small enough mesh to keep out mosquitoes and most other noxious insects and yet not be so small as to prohibit the passage of enough air for adequate ventilation.

In a search of literature and inquiries from different people of the Army, Navy, Air Force, U. S. Department of Agriculture and the U. S. Public Health Service as shown in the Appendix, there appeared to be little information on the subject. Because of this, we had to develop our own methods.

For the test purpose, a square wooden panel six feet on each side was built of plywood with a centered square opening of thirty inches on the side. Copper screens of 16x16, 18x18, 22x22 and 24x24 mesh per inch were attached to frames that would fit in the panel opening. One frame with a screen of vinyl-plastic coated fiberglass with a 14x18 mesh size was also used.

The panel was set up 25 feet in front of a high-speed fan blower and the velocity of the air coming through the opening was measured with an anemometer held

six inches behind the center of the opening for one minute intervals. The different size mesh screens were then placed in the opening and the velocities were recorded six inches back of them. Several readings were made of each screen as well as of the unscreened opening before and after putting in each screen and an average was computed. A speed of 5040 ft/min or 57.7 mph was used.

The panel was placed six feet from a high speed fan blower which was run at an idling speed, blowing air through the opening at a velocity of 1500 ft/min or 17.1 mph and the above procedures repeated. Speeds of 1780 ft/min-20.1 mph and 2080 ft/min-23.8 mph were also used similarly.

An 18-inch electric fan was placed on a box eight feet from the panel and the procedure repeated using velocities of 675 ft/min-7.7 mph and 420 ft/min-4.8 mph.

The velocities of the air coming through the screens were subtracted from the velocities without the screens to find the differences or losses caused by the screens. The losses were divided by the velocities without screens to determine the percentage of air held back by each mesh screen. (Table 1.) Results were plotted (Fig. 1) using mesh size of the screen as one ordinate and percentage of air held back as the other.

Diameters of the filaments and sizes of the apertures were also measured. This

TABLE 1.—Reduction of air flow by insect screens of various meshes and at different velocities
July-August, 1955

Velocity MPH	Percent Reduction at Meshes of—				
	16 × 16	18 × 18	14 × 18	22 × 22	24 × 24
57	5	13	29	31	36
24	18	19	29	31	34
20	9	18	28	37	42
17	5	23	31	41	45
8	17	33	39	43	48
5	25	27	36	52	54
Avg. 21.8 mph	13.1%	22.2%	32.0%	39.2%	43.2%

was done by placing the screens under a magnification of twenty, measuring ten horizontal and ten vertical filaments at random and taking the maximum, minimum and mean. The apertures were measured in the same manner.

The results, as would be expected, show that the finer the mesh of screen the greater the reduction of air penetrating it. For example, at 17 mph with a 16x16 mesh screen, 5 percent of the air was held

back while at the same velocity a 24x24 mesh screen held back 45 percent of the air. Figures also show that a larger percentage of air is kept from entering the screens at a low velocity than at a high one.

Preliminary work on insect penetration of various mesh screens was done using *Aedes aegypti* mosquitoes. In the first tests no penetration of insects through meshes finer than 18x18 occurred. Re-

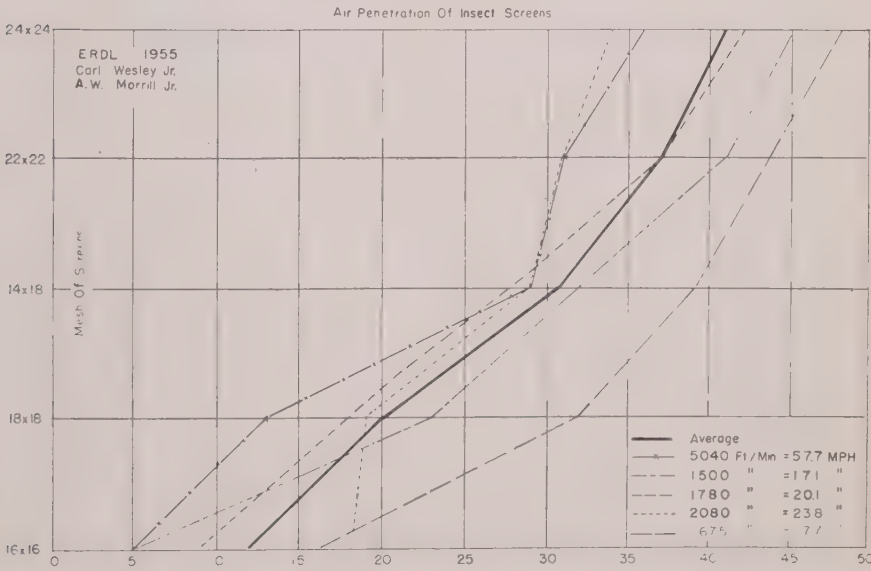


Figure 1% Reduction Of Air Caused By Screens

sults of work done by Knipling at USDA Laboratories at Orlando, Florida, in 1945 using *Aedes aegypti* as test insects also showed that screens of mesh coarser than 18x18 were not satisfactory in restricting the mosquitoes.

From the results of above tests it is concluded that screens of 18x18 mesh should be used to exclude the majority of insects and yet permit enough air for pleasant ventilation.

Appendix

Agencies Solicited for Information

1. Army Medical Laboratory
Army Chemical Center, Maryland
2. Army Quartermaster Research and Development
Natick, Massachusetts
3. Navy Preventive Medicine
Naval Air Station
Alameda, California
4. Navy Preventive Medicine
Naval Air Station
Jacksonville, Florida
5. National Advisory Committee for Aeronautics
Washington, D. C.
6. Civil Aeronautics Administration
Washington, D. C.
7. Army Office Chief of Engineers
Research and Development
Repairs & Utilities
Washington, D. C.
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Fort Belvoir, Virginia.

EFFECTS OF VARIOUS INSECTICIDE SOLUTIONS ON DIFFERENT KINDS OF INSECT SCREENS

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As part of its program of insect and rodent control equipment and methods, the Sanitary Engineering Branch of the Engineer Research and Development Laboratories, Fort Belvoir, Va., investigated the effects of various insecticide solutions on different kinds of insect screens for the purpose of determining whether insecticide solutions would corrode metal screens or soften or dissolve plastic and and plastic coated screens.

The kinds of screens tested were as follows: A. Copper; B. Brass; C. Bronze; D. Galvanized; E. Saran; F. Vinyl Plastic Coated Fiberglass; G. Aluminum.

The screens were framed in wood and

set up in wooden racks (Fig. 1) at the following locations where insecticides were first applied to them on the given dates: 1. Fort Belvoir, Va., May, 1954; 2. Fort Churchill, Canada, June, 1954; 3. Yuma, Arizona, Oct., 1954; 4. Coco Solo, C. Z., Nov., 1954.

Screens in some barracks and mess halls were also treated with insecticides at the military installations at Miami Beach, Florida, starting in May 1955, at Fort Baker, California in February 1955, and at Fort Sam Houston, Texas in August 1955.

Tests were performed at Fort Churchill and Yuma by the Corps of Engineers



FIG. 1. Arrangement of screen rack for tests of insecticide solutions.

Field Test Teams, Arctic and Desert respectively; those at Miami Beach, Florida, by District Engineer personnel; Fort Sam Houston, Texas, and Fort Baker, California, by Post Engineer personnel; those at Fort Belvoir, Virginia by ERDL personnel; and the ones at Coco Solo, C. Z., by personnel of the Naval Research Laboratory.

INSTRUCTIONS. The initial application of insecticides was made by one of the authors of this paper at each of the test sites, where the following instructions were given, under the heading "Insecticide Treatment of Insect Screens":

1. The upper panel of screen set will be treated with various forms of insecticides, their effects on the screens will be observed on monthly inspections, and these effects will be noted in monthly reports.

2. Mark out vertical lanes on upper panels by means of strings or wires attached to the wooden frames. The width of the lanes will be four inches, with approximately one and one-third inches of untreated space between lanes.

3. Insecticides used will be as follows:

- a. DDT in kerosene, 5 percent—Quartermaster issue
- b. DDT emulsion, 5 percent with xylene as solvent—1 part and 4 parts H_2O
- c. DDT wettable, 5 percent—1 lb. 50 percent powder and 1 gal. H_2O
- d. DDT 5 percent, Chlordane 2 percent—Quartermaster issue

4. Application of insecticides should be made with a soft paint brush of about three inches to both sides of the screens starting from the bottom of the panel and working up to keep solutions from running down onto the frame and lower panel.

5. Reapply insecticides every sixty days during insect season exactly as applied initially.

6. In regular monthly inspection the following should be observed and reported.

- a. Severance of yarn fibers
- b. Dissolving of plastic coating
- c. Tackiness of coating
- d. Corrosion or discoloration of screen
- e. Any dimensional distortion
- f. Any unusual occurrence not covered by inspection check sheet

OBSERVATIONS. Besides receiving and evaluating monthly reports (for over a year in some cases) the authors have visited each of the locations of the screens, observed them, and consulted with the people performing the tests.

The first effects of the application of insecticides to the screens were a white appearance to the screen treated with wettable powder and a darkening of the screen treated with emulsion. These effects were noted at all test sites. The discolorations to the screens were removed easily by scrubbing with a brush, soap and

water. A heavy coating of pollen or "arctic cotton" adhered to some of the screens at Fort Churchill, but it was also easily removed by cleaning. After the removal of the discolorations on the screens by scrubbing they had a similar appearance to the untreated screens, but were somewhat cleaner. The metal screens were not rusted or corroded and no softening or dissolving of the plastic or plastic coated screens was observed.

Treatment of the screens will continue at the several test sites during their insect seasons, the screens will be inspected

by testing personnel, and any unusual occurrence will be noted and reported. However, monthly reports will be replaced by semi-annual ones. The test sites will also be visited every six months by ERDL personnel who will inspect and evaluate the tests with the local people.

To date, negligible changes have occurred in the screens—metal, plastic, or plastic coated because of insecticide applications to them. As a result of the described tests it is concluded that the insecticides used have had no harmful effects on the insect screens.

THE CHALLENGE OF GLOBAL MALARIA ERADICATION

DONALD R. JOHNSON¹

During the past ten years, many nations of the world have initiated or expanded malaria control campaigns because of the effective control made possible by the development of DDT and related materials. Residual insecticides applied to the inside wall surfaces of dwellings provided control that previously appeared impossible. Even though these materials are effective and economical, many governments have insufficient means to carry out the necessary programs.

In order to assist countries otherwise unable to establish and maintain anti-malaria campaigns, vector control specialists and commodities have been provided by the coordinated action of the World Health Organization (WHO), the United Nations Children's Fund (UNICEF), the U. S. International Cooperation Administration (ICA) and other organizations. At the present time it is estimated that of

the approximately 600,000,000 persons living in areas requiring malaria protection outside of communist countries, more than 260,000,000 are receiving such protection (4). Our government through ICA is providing direct support to 20 countries of the free world for malaria programs in which it is estimated that more than 175,000,000 persons are receiving protection. The most extensive campaign is in India where 136,000,000 persons already are within the program. In addition, the Philippines, Taiwan (Formosa), Vietnam, Cambodia, Laos, Indonesia, Thailand, Pakistan, Nepal, Iran, Jordan, Ethiopia, Liberia, Mexico, Honduras, Colombia, Peru, Haiti, and Ecuador are receiving aid. WHO and UNICEF also provide assistance to some of these and other countries. The Pan American Sanitary Bureau (PASB), which is the Regional Office for the Western Hemisphere for WHO, is taking an active lead in many of the programs in Latin America.

The tremendous success of malaria con-

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trol operations throughout the world has encouraged governments and international organizations to endorse and promote a change from control of malaria to eradication of malaria. At the Eighth World Health Assembly held in Mexico City in May, 1955, a resolution was approved by the official delegates of 46 nations recommending that governments intensify plans of nation-wide malaria control in order to achieve eradication before the anopheline vectors are no longer susceptible to control by the residual insecticides. The Assembly also authorized the Director-General of WHO to request governments of countries where malaria still exists to give priority to malaria eradication projects in their requests for assistance under the United Nations Expanded Programme of Technical Assistance.

The eradication concept is under intense consideration in many countries at present. Taiwan and Ceylon have nearly attained this goal and others are proceeding with eradication programs. Mexico has an ambitious five-year program in which the elimination of malaria from 17,000,000 persons is planned. The Philippines, Iran, Thailand, Jordan, and Haiti are examples of countries receiving U. S. aid where eradication is being stressed.

Even though governments have the best of intentions to eradicate this mosquito borne disease, many difficulties lie ahead. The most important of these are as follows:

1. ANOPHELINE RESISTANCE TO INSECTICIDES: DDT has been the principal insecticide used for residual applications and has made possible the tremendous success of malaria programs. However, after several years of use, anopheline mosquitoes have been shown in some areas to be resistant to DDT. The resistance of *Anopheles sacharovi* to DDT in Greece was suspected first in 1951 (2). In 1954 Crandell (1) reported the resistance of *A. sundaiacus* to DDT in Indonesia. Dieldrin is now being used effectively in Indonesia to control the DDT resistant *A. sundaiacus* adults but it is not known

how long before they will develop dieldrin resistance. Other reports indicate chlorinated hydrocarbon resistance in several other species of anophelines elsewhere. The most recent report was given at the WHO Conference on Malaria in Africa, held in Nigeria, November 28-December 6, 1955. It was reported by Elliott and Ramakrishna (3) that in Western Sokoto (Nigeria) *A. gambiae* has developed an increased specific resistance to dieldrin with an evident though less marked resistance to DDT. Despite these alarming reports, DDT and dieldrin continue to be the insecticides of choice in most areas of the world. Resistance generally is localized but can be expected to spread. It is hoped that resistance will not become too widespread before eradication is attained in many areas.

The development of this physiological resistance by mosquitoes to the chlorinated hydrocarbon insecticides generally is given as the principal reason for the present emphasis on a shift from control to eradication programs. Resistance, of course, makes control more difficult. It may be necessary to substitute other insecticides such as organic phosphate compounds, increase the use of antimalarial drugs, or return to the use of antilarval measures. In any event, the development of resistance is not a hopeless problem.

2. AVAILABILITY OF TRAINED PERSONNEL: In most of the countries having a malaria problem, there is a wealth of labor but an acute shortage of trained professional personnel capable of providing the necessary technical leadership for malaria campaigns. However, training programs for professional persons are available in various parts of the world and gradually the number of trained individuals is increasing. Funds are necessary for this training but it appears that there is an awareness of this need and, therefore, funds are being obtained both within countries and from international organizations.

3. HUMAN BEHAVIOR CHARACTERISTICS: Malaria eradication is made more difficult

by the frequent moving of certain peoples from one area to another, carrying malaria with them. Nomadic tribes and persons displaced by wars or political upheavals move from malarious to nonmalarious sections of countries and vice versa. Another problem is that many people sleep out of doors in some countries thereby precluding effective use of residual insecticides inside of dwellings. Antimalarial drug administration may be the solution both to the movement of populations and out-of-door sleeping, provided that such chemotherapy programs can be organized and administered properly.

4. **AREA INACCESSIBILITY:** Ideal malaria eradication programs should include widespread areas, thereby necessitating the crossing of various geographic boundaries. This is not always possible, particularly during present national and international tensions. It is hoped that eventual easing of such tensions will alleviate these situations. Neighboring countries in some instances already are cooperatively combatting malaria along common borders. Cooperative programs are imperative if malaria is to be eradicated.

There is another type of inaccessibility created by geographic obstacles such as mountain ranges. As countries continue to develop, water transport is improved, roads are built, railways are extended, and air fields are constructed. For these reasons geographic obstacles gradually are disappearing. Even so, there are places in the world such as the interior of Africa where it may not be feasible to attempt programs for many years to come.

5. **ATTITUDE OF GOVERNMENTS:** Even though many governments presently are pursuing vigorously malaria eradication programs, there are others showing some apathy toward these campaigns. For success, countries must give wholehearted support to the idea of eradication. Instead of decreasing control activities when eradication is within sight, campaigns must be maintained and extended even to the most remote areas. Usually the areas most difficult of access or where the

population is sparse are left until last. Antimalarial programs leading to eradication are more tedious than normal control operations and per capita annual control costs are higher for several years. However, efforts are being made to demonstrate to government officials that intensified eradication campaigns will be cheaper in the long run and actually can be looked upon as capital investments which will pay for themselves many-fold during years to come.

Even when eradication is attained, an antimalaria organization should be maintained so that cheaper surveillance programs can be put into effect. The surveillance group must be ever alert to reintroduction of malaria and be prepared to take the necessary measures to combat it so that previous efforts will not be lost.

6. **AVAILABILITY OF FUNDS:** As mentioned above, antimalarial operations pay for themselves many-fold. Even so, some governments do not have funds for this type of investment which usually requires foreign exchange and import of experts from abroad. For this reason international organizations have provided generous amounts of funds for commodities and technical assistance. However, there is no assurance that this aid will continue indefinitely. It is hoped that international aid will be continued until countries are financially able to maintain the programs with their own resources.

CONCLUSIONS: Even though there are real obstacles to be overcome, it has been demonstrated that malaria can be eliminated from countries or areas within countries. Insecticides which are effective, comparatively safe, and economical are available. Many organizations now are providing the necessary leadership and funds to assist the less developed countries with their programs. Dr. Paul F. Russell of the Rockefeller Foundation recently expressed this very aptly when he said that these conditions have created the "golden moment" in the history of malaria control and we should not miss the opportunity to eradicate malaria wherever possible.

The members of the American Mosquito Control Association should have a real interest and pride in these programs. Many of the control methods being used so successfully overseas were developed by mosquito control personnel in the United States. Some of our Association members are providing technical direction to the programs in various countries. Insecticides, sprayers and other equipment manufactured in this country are being used to achieve control and eradication. These programs are helping less developed countries of the free world remain free by helping them attain good health and thereby permitting them to progress toward economic self-sufficiency. Global malaria eradication is a stimulating challenge to professional mosquito control personnel everywhere. As members of the Associa-

tion and citizens of the United States, we are helping to meet this challenge and it is hoped that we can continue to do so until malaria is no longer a world-wide threat.

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ARTICLES

EFFECTIVENESS OF A PRE-HATCHING TREATMENT FOR THE CONTROL OF SALT-MARSH MOSQUITOES IN FLORIDA

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Salt-marsh mosquitoes are major pests of man in most of the coastal areas of Florida. *Aedes taeniorhynchus* (Wied.) and *Aedes sollicitans* (Wlkr.) comprise the major populations along the Atlantic seaboard. These insects are not known to be vectors of any disease in this state, but they are a constant source of annoyance throughout the year.

In February and again in May 1955, the U. S. Air Force conducted a pre-hatching experiment in the vicinity of Patrick Air Force Base in Brevard County, Florida, to control salt-marsh mosquito breeding. Three chlorinated hydrocarbon insecticides were selected for use. These were dispersed by the USAF Special Aerial Spray Flight¹ over individual experimental plots at the rate of one pound insecticide per acre.

Researches on the residual toxicities of various insecticides and their value in pre-flooding or pre-hatching treatment for the control of mosquito larvae have been conducted in the past. This method was first used with favorable results by Wisecup and Deonier (1944) on small breeding places of *Psorophora* in Florida. Shortly afterward Wisecup, *et al.* (1945) found that pre-hatching treatments with DDT sprays applied by airplane effectively controlled mosquitoes in Arkansas rice fields. Poor control of the salt-marsh mosquitoes

Aedes taeniorhynchus (Wied.) and *Aedes sollicitans* (Wlkr.) was obtained in Florida with light applications of DDT (Wisecup *et al.* 1947), but in 1948, Deonier *et al.* concluded from their experiments using 10 percent DDT dust at one pound of DDT per acre that pre-hatching treatments with DDT dust might be very effective for use against the same species. This method was also effective against floodwater *Aedes* along the Columbia River in Oregon (Yates & Gjullin 1947). In New Jersey promising results against fresh-water swamp mosquitoes were obtained with DDT but not with benzene hexachloride (Hansens & Hart 1947).

Lindquist, *et al.* (1948) reported complete control of *Aedes* mosquitoes with DDT applied at the rate of 0.5 to 1 pound per acre in pre-hatching experiments conducted in Washington and Oregon against snow-water or mountain species. McDuffie *et al.* (1949) recorded the results of pre-hatching treatments for the control of Arctic mosquitoes. A series of insecticides in the chlorinated hydrocarbon group was tested in addition to parathion. The results obtained indicated that this form of treatment was applicable against *Aedes* mosquitoes in northern Canada. Comparable results were reported by Travis, *et al.* (1949) for tests conducted in Alaska during 1947 and 1948.

According to Deonier, *et al.* (1950), observations during June of 1949 in Brevard

¹ Commanded by Captain Russell J. Merriken, USAF, Langley Air Force Base, Virginia.

County, Florida, indicated that the conventional dissemination of DDT from aircraft was not controlling larvae or adults of the salt-marsh mosquitoes so well as in previous years. This was noticed particularly in the vicinity of Cocoa Beach, where DDT had been applied on a small scale as early as 1943 and 1944, and extensively since 1945. During the seasons of 1950-1952 small and large-scale tests with most of the available insecticides were carried out in this area against both larvae and adult mosquitoes. Benzene hexachloride (33 percent gamma isomer) has been used almost exclusively throughout the area for routine control of mosquitoes since 1951.

McDuffie and Keller (1952) offer a comprehensive review of mosquito control measures in Florida. This review includes the Cocoa Beach area. Extensive tests to compare the effectiveness of DDT, dieldrin, and toxaphene as prehatching agents were conducted during 1950 and 1951. Dieldrin was found to be slightly more effective than toxaphene and both were superior to DDT. It was concluded that prehatching treatments might be used advantageously against salt-marsh mosquitoes in areas that are inaccessible during the active season, or are too extensive for

adequate coverage with limited equipment and personnel.

The purpose of the current series of experimental flights was to evaluate the comparative residual capacities of benzene hexachloride (42 percent gamma isomer), dieldrin, and lindane, and to determine their applicability as prehatching agents in this region. This is a preliminary study and it is anticipated that it will be a guide to further studies along the same line.

For the purpose of these experimental flights, C-47 aircraft assigned to the USAF Special Aerial Spray Flight based at Langley AFB, Virginia, were used. The dispersal equipment consisted of the boom spray system with the insecticide being dispersed under pressure.

Solutions of the three insecticides selected were prepared using No. 2 fuel oil as the vehicle. Actual formulations are listed in Table 1.

Three 267-acre plots were designated as the experimental areas. These were widely separated from one another so as to preclude drift of insecticide from one plot into the next. Experimental Plot I was sprayed with a 20 percent dieldrin solution. This area was located on the south end of Patrick Air Force Base and

TABLE 1.—Data on the application of the chlorinated hydrocarbon insecticides used in prehatching experiment. Brevard County, Florida. 1955.

Insecticides and Formulation (Solutions)	Rate of Application	Plot Number	Area Treated	Date of Treatment	Surface Temp. (°F)	Surface Wind (Knots)	Vegetation
20% Dieldrin in No. 2 Fuel Oil (1.68 lbs. dieldrin per gallon)	1 lb. dieldrin per acre	I	267 Acres	22 Feb 1955	67	11	Salt-marsh Bermuda; white mangrove
				12 May 1955	80	7	
20% Lindane in No. 2 Fuel Oil (1.68 lbs. lindane per gallon)	1 lb. lindane per acre	II	267 Acres	22 Feb 1955	67	11	Salt-marsh pickleweed some white mangrove
				12 May 1955	80	7	
8% Benzene Hexachloride in No. 2 Fuel Oil (0.66 lb. BHC per gallon)	1 lb. BHC per acre	III	267 Acres	22 Feb 1955	67	10	Salt-marsh pickleweed; some white mangrove
				12 May 1955	80	7	

on the Banana River side of the peninsula. Plot II was located about one mile south of the Cocoa Causeway. This plot was sprayed with a 20 percent lindane solution. Plot III was sprayed with an 8 percent benzene hexachloride solution. This area was located one mile north of the Cocoa Causeway and like the other two, faced on the Banana River. The untreated areas surrounding the experimental plots were used for control.

The plots were located in open areas and included marshes overgrown with pickleweed, *Batis maritima* L., or salt-marsh bermuda, *Distichlis spicata* L., with occasional stands of mangrove, *Rhizophora mangle*. Plot I contained a relatively heavy growth of mangrove with some salt-marsh bermuda while Plots II and III were covered primarily with salt-marsh pickleweed.

Pre-spray surveys were conducted on each of the three plots to establish existing adult and larval populations prior to treatment.

To determine the efficacy of the treatments and test the virility of the insecticides, both larval and adult mosquito counts were taken 21 days after the February application and 39 days after the May application. Collecting stations were established both within each of the experimental plots and in the control areas surrounding them. The locations of these stations are indicated by the circled numbers in Plate 1.

Survey procedures and count techniques were as follows: Larval dip collections were made daily at a pair of the stations inside the treated areas and the totals averaged. This figure was compared with a figure derived in a comparable manner from dips made from two stations in the adjacent control zone. The collecting points were varied from day to day so as to insure coverage of all stations once every five days. Adult biting counts were registered simultaneously and at the same stations with the larval counts. These collection figures are listed in Plate No. 2 and Plate No. 3 and the conclusions were based upon comparison of both the larva

and adult population curves. The curves of those populations in the treated areas were compared first of all against those of their companion control areas and finally against one another to determine relative toxicities and residuals.

Collection data accumulated during the periods of observation included Ground Temperature, Surface Winds, and Total Precipitation in addition to insect counts. The statistical tabulations of the ecological factors may be summarized as follows:

Initial Application: 23 February through

15 March

Ground Temperature

0900 Hours

High: 76 F.

Low: 59 F.

Average: 70.2 F.

1600 Hours

High: 86 F.

Low: 65 F.

Average: 73.4 F.

Surface Wind (Average Velocity):

9.5 knots

Precipitation: None

Second Application: 13 May through
20 June

Ground Temperature

0900 Hours

High: 85 F.

Low: 71 F.

Average: 80.4 F.

1600 Hours

High: 84 F.

Low: 70 F.

Average: 80.7 F.

Surface Wind (Average Velocity):

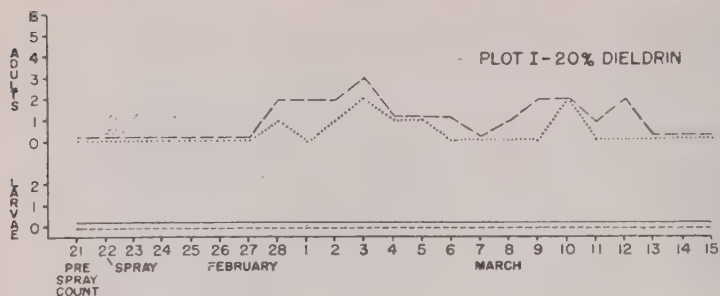
10.3 knots

Precipitation (Average): 0.14 inches/
24 hour period with $\frac{1}{2}$ inch or better
recorded on 15 May (0.52 in.),
22 May (0.72 in.), 12 June (0.60
in.), 17 June (1.04 in.), 19 June
(0.72 in.), and 20 June (0.94 in.).

RESULTS. A review of the data for the February treatment (Plate No. 2), shows that the experiment was abortive due to the lack of breeding following treatment. The three 267-acre test plots were not

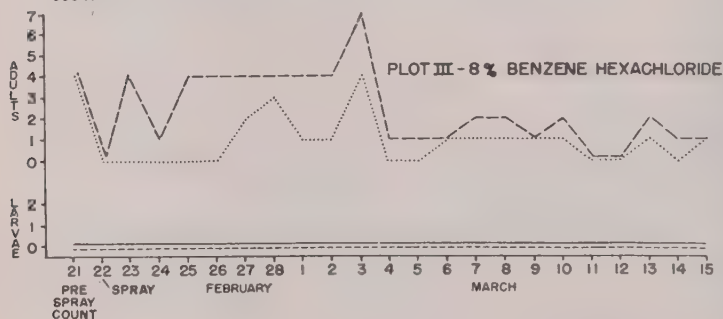
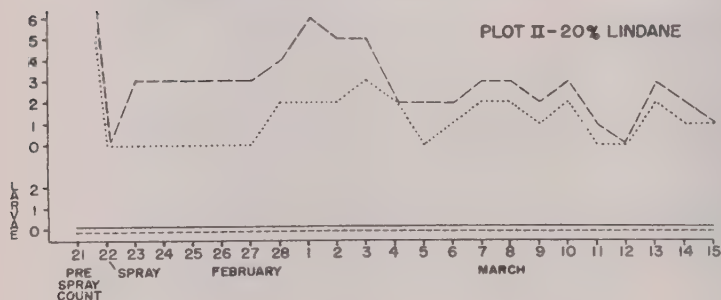


PLATE 1. Aerial photograph showing the sites of both the experimental and control plots as well as the approximate locations of the adult biting and larva dip stations.



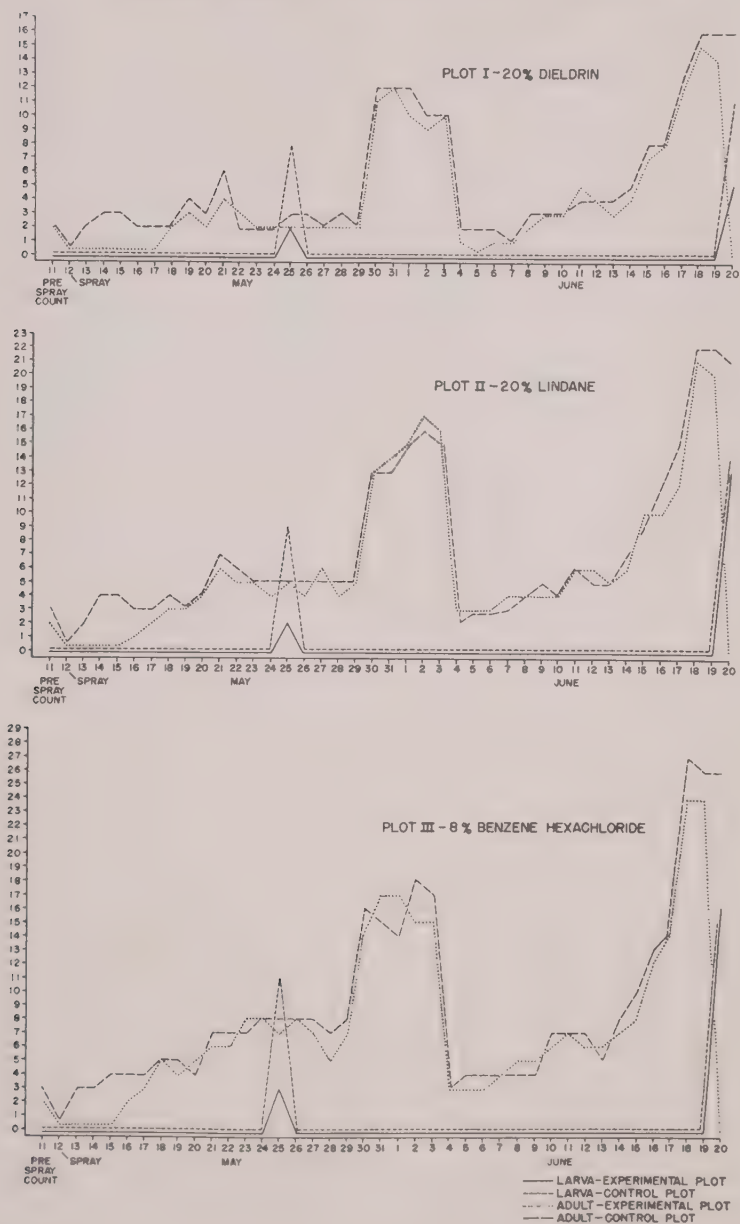
16
15
14
13
12

PLATE 2. MOSQUITO POPULATION COUNTS FOLLOWING THE INITIAL APPLICATION OF THE THREE CHLORINATED HYDROCARBON INSECTICIDES USED IN THIS PREHATCHING EXPERIMENT. BREVARD COUNTY, FLORIDA. FEBRUARY 1955.



— LARVA-EXPERIMENTAL PLOT
 --- LARVA-CONTROL PLOT
 ADULT-EXPERIMENTAL PLOT
 --- ADULT-CONTROL PLOT

PLATE 3. MOSQUITO POPULATION COUNTS FOLLOWING THE SECOND APPLICATION OF THE THREE CHLORINATED HYDROCARBON INSECTICIDES USED IN THIS PREHATCHING EXPERIMENT. BREVARD COUNTY, FLORIDA. MAY 1955.



flooded at the time the insecticides were applied; only small quantities of water were present in isolated depressions or potholes. Precipitation during the subsequent 29-day period was negative, and no breeding was observed. No conclusions could be made with respect to larval mortality due to this condition. No adult mosquitoes were collected from Plot I until 6 days following application of dieldrin. Both lindane and benzene hexachloride were effective adult control agents. In Plot II lindane provided immediate reduction and complete control for 5 days following application. Benzene hexachloride (Plot III) was only slightly less toxic in that the adult population was negative until the fifth day following treatment.

Analysis of the May-June treatment shows two flood periods. One occurred 10 days and the second 36 days following the date of application of the insecticides. Buildup of larval populations in each experimental plot was observed 3 days subsequent to each flooding date. Negative larval counts were made in each experimental plot on the fourth day following the initial flooding. This reduction in larval counts can be attributed to the rapid run-off and absorption which quickly restricted larval environments to small, protected pockets of water and precluded collection at the designated stations.

While the larvae collection curves were negative for both the control as well as the experimental plots between floodings, the population differentials for each pair on the third day following flooding were marked. Counts made following the floodings were:

Plot	Insecticide	Experimental Plot No. (aver. larvae/ dip)	Control Plot No. (aver. larvae/ dip)	Differential
Initial Flooding				
I	Dieldrin	2	8	75.0%
II	Lindane	2	9	77.8%
III	Benzene Hex.	3	11	72.8%

Second Flooding

I	Dieldrin	5	11	54.6%
II	Lindane	13	14	7.1%
III	Benzene Hex.	16	15	6.2%

On the basis of these data, each of the three insecticides showed a comparable degree of effectiveness after the first flooding. Only dieldrin, however, was effective in the control of larvae after the second flooding.

Comparison of the adult mosquito population curves shows an immediate reduction for each treated plot followed by rapid buildup and then close individual paralleling for each pair of control and experimental plots beginning the sixth day following treatment. Since the adult populations are similar in number and pattern for each of the three areas, it appears that they reflect a generalized distribution of itinerant populations infiltrating from the adjacent untreated areas.

The insecticides had no obvious effect on the adult populations in any of the experimental plots following the 22 May flooding. It is significant, however, that the adult population counts for each experimental plot were abruptly reduced to zero on the third day following the 17 June flooding. This would indicate that while none of the insecticides other than dieldrin was effective as a pre-hatch larvicide past the initial flooding, each of the insecticides was present in sufficient residual to poison all of the adults in each experimental plot after the second flooding.

SUMMARY. Field tests were conducted in Brevard County, Florida, during February and May of 1955, to determine the comparative residual effectiveness of three chlorinated hydrocarbon insecticides (benzene hexachloride, lindane, and dieldrin) against the larvae of salt-marsh mosquitoes, *Aedes taeniorhynchus* (Wied.) and *Aedes sollicitans* (Wlkr.). These poisons were applied under pressure at the rate of one pound per acre in No. 2 fuel oil as a pre-hatch treatment from a C-47 type aircraft equipped with underwing discharge booms.

The test plots contained 267 acres each and were located in typical salt-marsh breeding areas covered with pickleweed, *Batis maritima* L., salt-marsh bermuda, *Distichlis spicata* L., or white mangrove, *Rhizophora mangle*. The February treatment was followed by a comparative drought. Treatments were repeated in May. Only the data from the second treatments which were effected ten days prior to the first flooding are considered in this report.

All three of the insecticides tested gave effective control of larvae after the first flooding. Surveys made following the second flooding which occurred 27 days after the first showed extensive breeding in the plots originally treated with lindane and benzene hexachloride while the plot treated with dieldrin showed a 55 percent differential in larvae.

Results of this experiment indicate a variation in the comparative residual capacities of the three chlorinated hydrocarbon insecticides tested when the latter are applied as aerial sprays over salt-marsh areas.

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BIOLOGY OF THE PACIFIC COAST TREE HOLE MOSQUITO *Aedes varipalpus* (Coq.)¹

E. L. PEYTON²

DISTRIBUTION. The tree hole mosquito *Aedes varipalpus* (Coq.) is found on the Pacific Coast from Lower California to British Columbia, and in the states of Arizona and Nevada. It has been collected from sea level to an altitude of 7,200 feet (7). Only in the state of California does it occur in large enough numbers to cause a serious problem as a pest.

The following distribution records have been compiled from the literature and various other sources. County names are given, where known; otherwise the locality is named.

I. *Arizona* (3 records): Catalina Mts., Sabino Basin, and Cococino Co.

II. *British Columbia* (19 records): Capilano, Caulfields, Coquitlam, Davis Lake, Deroche, Ft. Langley, Harrison, Hatzie Prairie, Hope, Kalso, Kilgard, McConnell Creek, Mission, Nanaimo, Steelhead, Terrace, Vancouver, Victoria and Wellington.

III. *California* (45 records): Alameda Co., Amador Co., Butte Co., Calaveras Co., Colusa Co., Contra Costa Co., Del Norte Co., Eldorado Co., Fresno Co., Humboldt Co., Kern Co., Kings Co., Lake Co., Los Angeles Co., Madera Co., Marin Co., Mariposa Co., Mendocino Co., Merced Co., Modoc Co., Monterey Co., Nevada Co., Orange Co., Plumas Co., Riverside Co., Sacramento Co., San Bernardino Co., San Diego Co., San Joaquin Co., San Luis Obispo Co., San Mateo Co., Santa Barbara Co., Santa Clara Co., Santa Cruz Co., Shasta Co., Siskiyou Co., Solano Co., Sonoma Co., Stanislaus Co., Tehama Co.,

Trinity Co., Tulare Co., Ventura Co., Yolo Co., and Yuba Co.

IV. *Lower California* (2 records): Laguna, and Sierra Laguna (Cape Region).

V. *Nevada* (1 record): Glenbrook.

VI. *Oregon* (14 records): Ashford, Clackamas Co., Clatsop Co., Columbia Co., Jefferson Co., Klamath Co., Lincoln Co., Linn Co., Multnomah Co., Polk Co., Rockaway, Tillamook Co., Washington Co., and Yamhill Co.

VII. *Washington* (10 records): Jefferson Co., King Co., Kitsap Co., Lewis Co., Longmire Co., Mason Co., Pierce Co., Sakamania Co., Thurston Co., and Yakima Co.

LARVAL HABITATS. *Aedes varipalpus* breeds most commonly in holes in oak trees, but collections have been recorded for 17 different species of trees including sycamore, cottonwood, maple, buckeye, bay, elderberry, black walnut, English walnut, white fir, olive trees, eucalyptus, willow and California laurel. Although the true habitat of this mosquito is tree holes, on several occasions it has been taken from rock pools, barrels, and watering troughs (16); cemetery urns, and tin cans (12); sawed-off stumps (3); and a five-gallon paint can. All of the above mentioned cases were located near or beneath trees, and each had a heavy sediment of leaves which would seem to indicate that the species cannot survive without the elements supplied by either the trees or their leaves.

ASSOCIATIONS. Because of its restricted habitat, *Aedes varipalpus* is rarely found associated with other species of mosquitoes. Reeves (17) reports finding it on several occasions associated with *Orthopodomyia californica* Bohart, and *Culex quinquefasciatus* Say in tree holes. The

¹ Published under the auspices of the Surgeon General, U. S. Army who does not necessarily assume responsibility for the opinions expressed in this paper.

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writer has also found it associated with *Culiseta maccrackenae* Dyar and Knab in a five-gallon paint can.

DEVELOPMENT. Under optimum conditions *Aedes varipalpus* may pass through its life cycle in as short a time as 15 days. The duration of the pupal stage is five days. Hatching of the eggs occurs within about 12 hours; the eggs that do not hatch during this period will not hatch until they have been dried and flooded again. Normally, the breeding conditions in the field are so crowded that the emerging adults may be small enough to pass through an ordinary 18-mesh screen. On the other hand, if the food supply is sufficient for the number of larvae, larvae and adults may be comparable in size to the more common *Aedes* species.

SEASONAL OCCURRENCE. The seasonal occurrence of this species depends entirely upon weather conditions, and varies considerably in the different states. In many parts of the country there is usually no more than one brood a year, but under the proper conditions of rainfall as many as five distinct generations are possible as has been shown in a laboratory colony. Normally the adults reach a peak of abundance during the months of April and May. In California, adults have been collected every month of the year except November and December (7). Stage *et al.* (19) report that in Washington and Oregon west of the Cascades, larvae can be found almost any time of year. During the summer months, when rain is sporadic, larvae may survive for several weeks in the moist debris at the bottom of the tree hole (13), and this ability may enable them to survive until rain refills the hole.

In 1954, at Fort Baker (Marin County), California, adults did not begin to appear until the last of February, and reached a peak in numbers during April. The last larvae disappeared during the month of May. This might possibly indicate two generations for the year.

In the fall of 1954, the first rain sufficient to fill the tree holes in the Fort Baker area came in the early part of No-

vember. A group of selected tree holes was checked at this time and hundreds of first instar larvae were observed. These larvae remained in the holes until the following spring before completing development. The larvae that over-winter do not all transform to adults at the same time; thirty or more days usually being required before all the adults emerge. Larvae reared in the laboratory began hibernation during the first of November in 1954 and remained in the larval stage until the first of February 1955, at which time a few began to pupate. Pupation continued until the latter part of March 1955. Mortality was very low during the three to five months they were in the larval state.

The winter is passed in both the egg and larval stages, but it appears that most of the eggs hatch by spring as a result of the several successive wettings and dryings which occur during the fall and winter months. Stage *et al.* (19) report that the larvae may be found in mid-winter in the northwestern states if freezing temperatures do not prevail for long periods. In the higher altitudes and in most northern states where such conditions prevail, the few eggs that do not hatch during the fall rains are probably the only stage that survives the winters. This may be one of the primary reasons why this species has never been able to establish itself in large numbers in these states.

MATING HABITS. During the daytime the males are attracted to warm-blooded animals. They form small swarms around the animal and mate with the female when she approaches to feed. The males do not necessarily have to be swarming when mating takes place. On several occasions the males were observed alighting near a female at rest, and as the female went into flight the male would fly out and catch her. Copulation generally takes place while in flight; the act usually lasts from 30 to 60 seconds. On several occasions copulation was observed while the female was at rest feeding.

FEEDING HABITS. Very little is known of the feeding habits of *Aedes varipalpus*.

The females begin to take blood one to two days after emerging. They are vicious biters, and in some situations such as parks and summer camps located near wooded areas, the females are very troublesome. Feeding usually takes place during the daytime. Literature records many instances of this mosquito feeding on warm-blooded animals, but the kind of animal is never specified. The writer does not know of any host preference other than man, and it is assumed that any warm-blooded animal in the forested areas might be a source of blood for this species.

EGG LAYING. Eggs are laid five to six days after a blood meal has been obtained. Usually the female feeds at least twice during this period. The female lays her eggs singly on the side of the hole just above the water surface. The maximum and minimum numbers of eggs recorded for an individual female at one oviposition are 135 and 60 respectively. The total production of eggs recorded for an individual is 321 (16). The writer believes that under normal conditions a female is capable of producing many more than this. A small group of about fifteen females were kept alive in the laboratory for a period of 76 days. During this time they were fed raisin juice and rabbit blood. A large but undetermined number of eggs were obtained each day from this group.

RESTING AND FLIGHT HABITS. Apparently nothing is known of the resting habits of this species. Stage *et al.* (19) report that the adults have a restricted flight range.

ECONOMIC IMPORTANCE. The species has been found experimentally to be a vector of Western equine encephalomyelitis (19). It is also becoming a very important pest species in California.

STUDY OF IMMATURE STAGES. To facilitate study of the immature stages, a colony was established from larvae taken from tree holes, and was maintained throughout the year 1954. The adults were kept in cages 24 inches square. They were fed both human and rabbit blood. The fe-

males showed a marked preference for human blood. The males were provided with soaked raisins suspended from the top of the cage.

Three types of containers were used in the first series for oviposition: A 400 milliliter beaker with moist cellucotton; a flat bottom feeding dish six inches in diameter and three inches in depth, containing damp wooden chips; and two well-dried bamboo joints approximately three inches in diameter and fourteen inches in depth with a small amount of water in the bottom. For the first series all larvae that hatched from these containers were counted; approximately 80,000 larvae were obtained. The bamboo joints proved much more successful than the other two. This was probably due to the dark, damp resting place it provided for the females, or to some undetermined factor. The only disadvantage found with the bamboo joints was the impossibility of counting the eggs produced. The containers were left in the cage for approximately three weeks and then flooded every seven to eight days thereafter. At the time of flooding the containers were removed from the cage, filled with water and allowed to set for twenty-four hours, then the water was poured into an enamel pan and the larvae were taken out. The containers were then returned to the cage along with the eggs that did not hatch. Each time the bamboo joints were flooded a number of eggs that did not hatch were washed loose. These eggs were filtered and placed in petri dishes with damp cotton for further conditioning. After this conditioning most of the eggs hatched. The productivity of this mosquito in the bamboo joints is shown by the following data from a single bamboo joint used in the first series. The data do not include larvae which hatched from eggs filtered and kept in petri dishes. The dates are the dates of flooding, the figures are the number of larvae which hatched: May 17: 304; May 25: 1679; June 7: 6200; June 14: 2632; June 23: 5903; July 8: 3000; July 19: 5023.

Studies have shown that for embryonic

development the eggs require a period of two to three weeks under moist conditions. At the end of this period approximately 95 percent of the eggs are viable and will begin hatching within 15 to 20 minutes after flooding with correctly prepared water. In a moist condition the eggs will remain viable for many months, or possibly years, but if allowed to dry they will remain viable for only a very short period. To show this difference in viability between dried eggs and eggs kept moist, Reeves (16) reports that eggs which had undergone the period of embryonic development were dried for nine months; at the end of this time most of the eggs were dead, but after one and one-half years eggs which had been kept moist were still 95 percent viable.

In order to prepare water for hatchings, dry leaves were collected from beneath trees, and a few leaves were placed in large metal pans of water for approximately five days. If the water was used two to three days after the leaves had been added, a much lower percentage of hatching occurred. Lowe (13) reports successful hatchings of eggs in tap water. Reeves (16) in a later paper states that "Distilled water or tap water does not hatch eggs regardless of being dried or kept moist." The writer was also unsuccessful in his many attempts to hatch eggs in tap or distilled water.

Larvae were reared in water prepared in the same manner as for hatching of eggs. After the leaves had been in the water for at least four days, freshly hatched larvae were placed in the pan. The protozoa and other aquatic life produced by the infusion leaves, provided sufficient food for the 15 to 20 days the larvae were in the pans. Larvae fed in this way were very healthy, and completed their life cycle in a very short time. If the water remained in the pans for more than 30 days all larvae remaining were transferred to new water. Other types of food such as dog biscuit and yeast were tried, but did not give satisfactory results. A light scum formed on the surface of the water, but this was re-

moved each day by drawing a paper towel over the surface.

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A STUDY OF *CULEX TRITAENIORHYNCHUS* OVIPOSITION ACTIVITY DURING 1955¹

H. D. NEWSON² AND T. E. BLAKESLEE^{3, 4}

The seasonal incidence of *Culex tritaeniorhynchus* Giles, the only mosquito to have been found naturally infected with Japanese B encephalitis in Japan, has been studied extensively. This species, which has not been found in Japan during the winter, first appears during early spring in extremely small numbers (1-8). Its initial appearance is indicated by the collection of females which have been taken as early as April 6 (1). Its incidence rapidly increases and reaches a peak in the Tokyo

area sometime between July 15 and August 7. Its numbers decrease sharply after this and it finally disappears in late fall. Larvae are normally found somewhat later than adults, although both have been collected as late as November 15. All of these studies have involved primarily observations of adults and larvae, with little attention to egg laying activity (1-8).

A study of oviposition activity was made during the summer and fall of 1955, with three objectives in mind: (1) to study the relationship between egg laying and temperature; (2) to observe the relationship between the decline in adult population and the decline in oviposition rate; (3) to determine whether the seasonal decline in oviposition activity is abrupt or gradual.

Two areas approximately 10 miles apart were selected for the study. One, located 25 miles north of Tokyo in the vicinity of Kawagoe, contained 57 concrete night soil tanks arranged in three double rows from which large numbers of *C. tritaeniorhynchus* egg rafts had been collected in previous years. The other area, approxi-

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mately 30 miles northwest of Tokyo in the vicinity of Johnson Air Force Base, contained 116 night soil tanks distributed in three locations northeast of the base. Each tank was approximately 5 feet long, 4 feet wide and 6 feet deep and was set in the ground with only 6 inches of its rim extending above the ground level. Both areas were within a 10 mile radius of Johnson Air Force Base and the general topography of that section was relatively flat.

For this reason, meteorological data from the weather squadron at Johnson Air Force Base were considered to be applicable to both areas and were used in the study (9).

METHOD. Egg raft collections were begun on July 11 in Kawagoe and were made daily except Sunday during July and August and daily during September and October. Collections from the Johnson Air Force Base area were begun on July 15

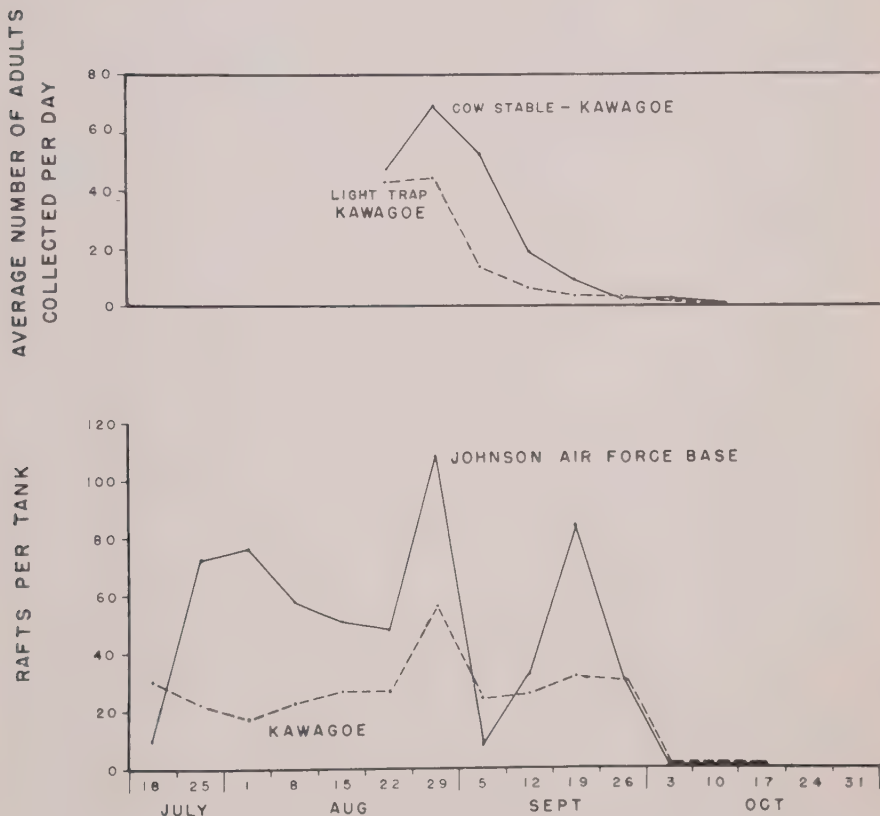


Fig 1. Culex tritaeniorhynchus adult and egg collections from KAWAGOE and egg collections from JOHNSON AIR FORCE BASE for week ending on date indicated

and were made 4 to 5 times each week. Egg rafts from each tank were collected in petri dishes containing moist filter paper, reared to fourth instar in the laboratory and identified.

Collection of adult *C. tritaeniorhynchus* was begun on August 16 in Kawagoe on the same schedule as were the eggs from that area. Adults were taken by a light trap located in the center of the tank area and from a cow stable approximately one hundred yards from the tanks.

Collections from both areas were discontinued on November 1.

RESULTS. Heavy oviposition was in progress and large numbers of adults were active at the time collections were begun. The average number of adults taken each day in Kawagoe and the daily average number of egg rafts collected per tank in Kawagoe and Johnson Air Force Base are presented for each week in Fig. 1. There were three peaks in egg raft collections from Johnson Air Force Base and two from collections in Kawagoe. Each from the latter area coincided with a collection peak at Johnson Air Force Base.

The major decline in egg raft collections from both areas took place during the two-week period of September 20 to October 3. Collections from Kawagoe declined from a daily average of 31 egg rafts per tank for the week ending September 26 to 1.28 for the subsequent week, while collections from Johnson Air Force Base declined from 30.5 egg rafts per tank to 0.87 during the same interval.

To study more closely this decline, the results of daily egg raft collections from both areas during this two-week period are presented in Fig. 2 with the daily maximum, mean and minimum temperatures and rainfall for the 12-hour period from 6 p.m. to 6 a.m. Since field observations during the course of this study indicate that this species oviposits during the hours from dusk to dawn, these results are considered to reflect the previous night's oviposition activity. For this reason weather data are presented for the 12-hour period 6 p.m. to 6 a.m. of the

night previous to the day the eggs were collected, rather than for the entire day. Egg collection data from Kawagoe for September 18 are omitted since 75 percent of the larvae from egg rafts collected from the area on that date died before they could be identified.

Collections from Kawagoe declined from an average of 26 egg rafts per tank on September 26 to zero on September 28. Daily egg raft collections from September 28 through October 10, when the last egg raft was found, averaged only 0.5 raft per tank and did not exceed 1.8 raft per tank on any day during this period.

Daily collections from Johnson Air Force Base declined from an average of 30 egg rafts per tank on September 26 to zero on September 27. While a few were collected at the daily rate of 0.60 raft per tank during the period of September 27 through October 10, when the last egg raft was taken, the collection rate did not exceed 8.7 rafts per tank on any day after September 27. A marked decline in temperature occurred during the nights of September 25-26 and September 27-28. A minimum temperature of 54.1° F. and a mean temperature of 59.4° F. were recorded during the 12 hour period ending 6 a.m. September 26. These were 3° and 2.3° lower respectively than had previously been recorded during the study. A mean temperature of 56.2° F. and a maximum temperature of 58.1° F. were recorded during the 12 hour period ending 6 a.m. on September 28. These were 3.2° and 8.4° lower respectively than had been recorded earlier in the study.

On the night of September 26-27, 0.5 inch of rain fell during the period of 6 p.m. to 6 a.m. and 0.93 inch fell during the same time period on the following night. This probably influenced the oviposition activity.

To study more closely the relationship of oviposition to temperature fluctuations, a number of tanks were examined at hourly intervals between 6 p.m. and 5 a.m. on August 29-30 and September 7-8. No eggs were observed before 6 p.m. or

after 5 a.m. Eggs were collected, the resulting larvae reared to fourth instar and identified. Egg laying was sporadic with 28 rafts being laid before 12 p.m. and 21 after this time. Only 49 egg rafts were collected from the study tanks during the two nights of observation. The small

number of egg rafts collected does not permit comparison of oviposition with temperature or humidity.

A total of 9,637 egg rafts were collected from Kawagoe, of which 65 percent were those of *C. tritaeniorhynchus*, 8 percent were those of other species, 15 percent

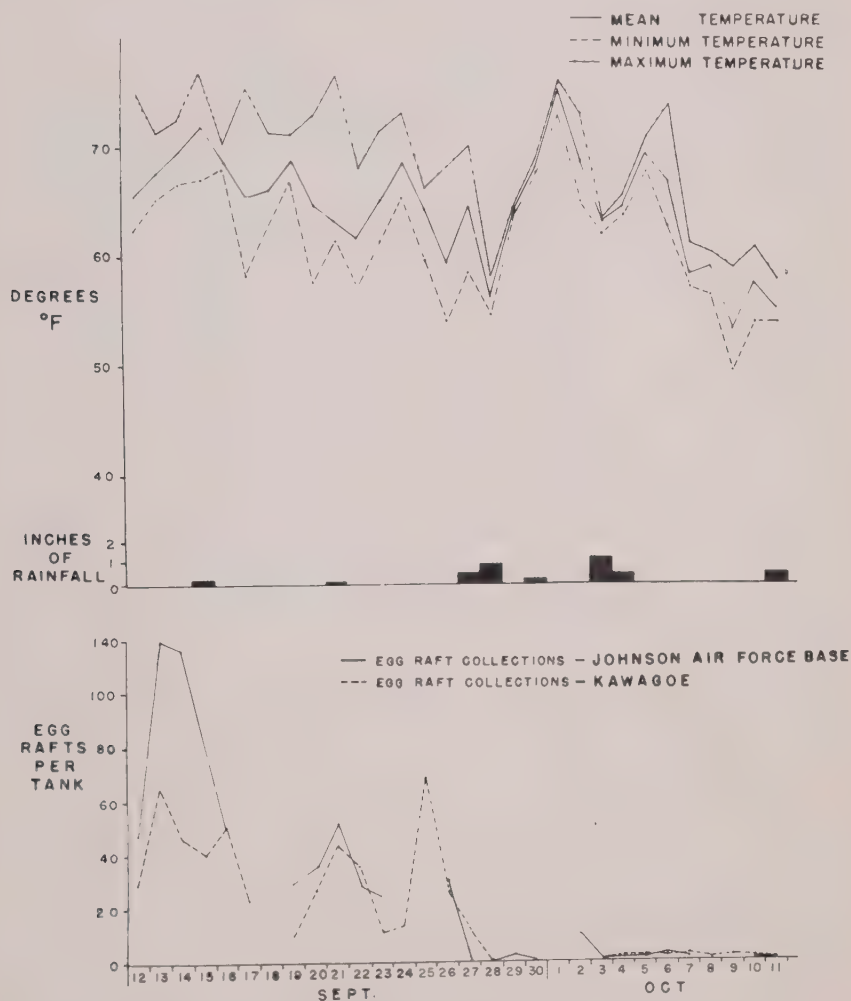


Fig 2 Daily *Culex tritaeniorhynchus* egg collections, rainfall, minimum, mean and maximum temperatures. Figures for temperatures and rainfall are for 12 hr. period ending 6 AM on date indicated

failed to hatch and 12 percent died before the resulting larvae could be identified. At Johnson Air Force Base, 7,599 egg rafts were collected, of which 74 percent were those of *C. tritaeniorhynchus*, 6 percent were those of other species, 10 percent failed to hatch and 10 percent died before they could be identified.

The number of adults collected at Kawagoe by light trap and from a cow stable declined rapidly after August 29. This preceded, by approximately three weeks, the general decline in egg raft collections from that area.

SUMMARY. Field studies of *Culex tritaeniorhynchus* oviposition activity were conducted in two study areas in the general vicinity of Tokyo during 1955. Egg raft collections declined abruptly in both areas, the decline occurring during September 26-28 in one area and September 26-27 in the other. Daily collections were negligible from September 28 through October 10 when the last egg raft was collected. Tanks were checked daily until November 1. A marked decline in temperature occurred during the nights of September 25-26 and September 27-28. A minimum temperature of 54.1° F. and a mean temperature of 59.4° F. were recorded during the 12 hour period ending 6 a.m. September 26. These were 3° and 2.3° lower respectively than had previously been recorded during the study. A mean temperature of 56.2° F. and a maximum temperature of 58.1° F. were recorded during the 12 hour period ending 6 a.m. on September 28. These were 3.2° and 8.4° lower respectively than had been recorded earlier in the study. Eggs were

collected at hourly intervals on two nights. Oviposition occurred sporadically throughout one night and continued until 2 a.m. on the other night.

Adults were collected by a light trap and from a cow stable located in one study area during the period in which egg rafts were collected. The decline in adult collections preceded the decline in egg raft collections by three weeks.

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OPERATIONAL AND SCIENTIFIC NOTES

FIELD OBSERVATIONS ON THE EFFECTS OF AN AROMATIC OIL HERBICIDE ON MOSQUITO PRODUCTION¹

BASIL G. MARKOS² AND ALLAN G. O'BERG, JR.³

Chemical herbicides are used extensively in California by irrigation districts and mosquito abatement agencies for the control of various weeds along the banks of irrigation canals and irrigation laterals.

Incident to other studies concerned with the prevalence and production of mosquitoes in cotton fields, an opportunity was afforded to observe the effects of an herbicide on mosquito production. Observations were limited to an irrigation lateral of one of the cotton fields (Sullivan) in West Fresno County.

This particular irrigation lateral was first flooded on July 14, 1955, and contained water for the remainder of the season. Flooding of the lateral was due to a faulty shut-off valve at the head gate, which allowed water to trickle from the main irrigation canal into the irrigation lateral.

Observations prior to September 24, 1955, indicated that this irrigation lateral was highly productive of two species of mosquitoes, namely, *Culex tarsalis* Coquillett and *Anopheles freeborni* Aitken.

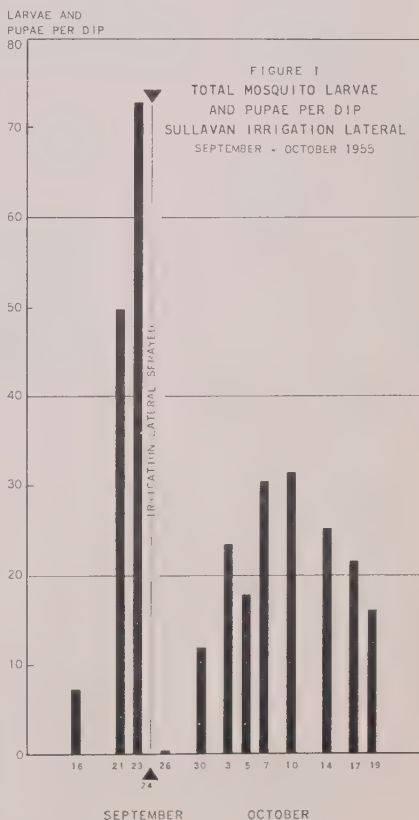
This summary accounts for the mosquito prevalence during the period of September 16 through October 19, and is based on data recorded for the express purpose of evaluating the toxic effects of the herbicide in the treated portion of the lateral.

In view of the fact that the irrigation lateral contained a considerable amount of vegetation scattered along the banks and also within the lateral, it was sprayed on September 24 by personnel of the Tranquillity Irrigation District. The material used was Kem-Kill "W" Aromatic Weed Oil, a formulation using General Petroleum's Aromatic Oil No. 10.⁴ A portable Bean sprayer was used to apply the oil. The spray

mixture was prepared by adding 75 gallons of concentrate to 225 gallons of water. Apparently only the upper two-thirds of the irrigation lateral was sprayed.

A residual odor from the herbicide application persisted for a long period of time as evidenced during subsequent inspections.

The data in Figure 1 show that excellent temporary control of the aquatic stages of both species of mosquitoes was obtained.



¹ The assistance of Mr. L. K. Stromberg, Associate Agriculturist, University of California, and Messrs. James H. Bray, Stanley G. Hanks and John R. Walker of the Bureau of Vector Control, is gratefully acknowledged.

², ³ State of California, Department of Public Health, Bureau of Vector Control.

⁴ Specifications: gravity (API) 14.6; flash (PMCC) 210° F.; viscosity (SSU @ 100° F.) 39.3; distillation (ASTM, 90%) 628° F.; water and sediment . . . trace.

There was no evidence that the egg rafts of *C. tarsalis* were affected by the treatment. It was also apparent that in spite of the pungent odors which were evident along the irrigation lateral, there was no discernible curtailment of oviposition by the females of *C. tarsalis*. Inasmuch as all of the culicine larvae taken were identified as *C. tarsalis*, the assumption is made that the culicine egg rafts were also exclusively *C. tarsalis*. While egg rafts were comparatively abundant at the time of the last two inspections prior to the treatment, a marked increase was noted during the first week following the herbicide application. Unfortunately, this weed control operation was not anticipated; thus, no pre- and post-treatment records of the number of adult mosquitoes in

and among the vegetation within the irrigation lateral are available for comparison.

Six days following the treatment, a considerable number of *C. tarsalis* larvae in first and second instars were found in the lateral. On the sixteenth day after treatment fourth instar larvae were fairly abundant and after twenty days pupae were in evidence.

In contrast, *A. freeborni* was much slower in re-establishing itself in significant numbers. A small number of first and second instar larvae were taken nine days after treatment. It was not until the thirteenth day that *A. freeborni* larvae were observed in significant numbers in the lateral. Fourth instars were seen on the twentieth day and pupae on the twenty-third day after application of the herbicide.

A PORTABLE ADULT MOSQUITO FEEDING UNIT

JACK COLVARD JONES¹

U. S. Department of Health, Education, and Welfare Public Health Service
National Institutes of Health, National Institute of Allergy and Infectious Diseases,²
Bethesda 14, Maryland

Knierim *et al.* (1955) describe a simple device for offering heated blood and other fluids to adult mosquitoes. Their feeding unit is not designed to fit into small cages and is essentially non-portable. The present note describes a modified Knierim feeding unit which is portable and adapted for insertion into small cages (e.g., 1 cubic foot).

As shown in figures 1 and 2, the portable feeder is made up of a round brass (or other metal) base (B), 4 inches in diameter and one-half inch thick, a removable and rotating upright arm (R), 4¾ inches high, with a rubber hand grip (G). A Y-shaped holding arm (HA), with a simple clamping device, is screwed to the top of the upright arm.

The thermostatic control unit (T) is manufactured by Fenwal, Inc., Ashland, Mass. (type

32,000 series). The details of this unit are shown in figure 3. It measures 4½ inches in length. It has a range of 0–200° F., is adjustable to 2° F., and carries a 250-watt load. Two 10-watt, wire-wound, 300 ohm resistors are hooked in series and operated on 115-volt line; with smaller-sized resistors this unit could as easily be operated by battery. The thermostat fits into a glass tube (figs. 1 and 2) around which cellulose cotton, sponges, or membranes may be wrapped.

The present portable feeding unit is easily constructed; does not require alterations of existing cages; is easily cleaned and stored; and since it is small, permits several units to be inserted so that different experimental fluids can be offered to mosquitoes at a single time.

Literature Cited

KNIERIM, J. A., LEA, A. O., DIMOND, J. B., and DE LONG, D. M. 1955. Feeding adult mosquitoes on preserved blood to maintain egg production. Mosq. News 15:176–179.

¹ I am much indebted to Mr. M. Meyers for his advice and for construction of the unit.

² Laboratory of Tropical Diseases.

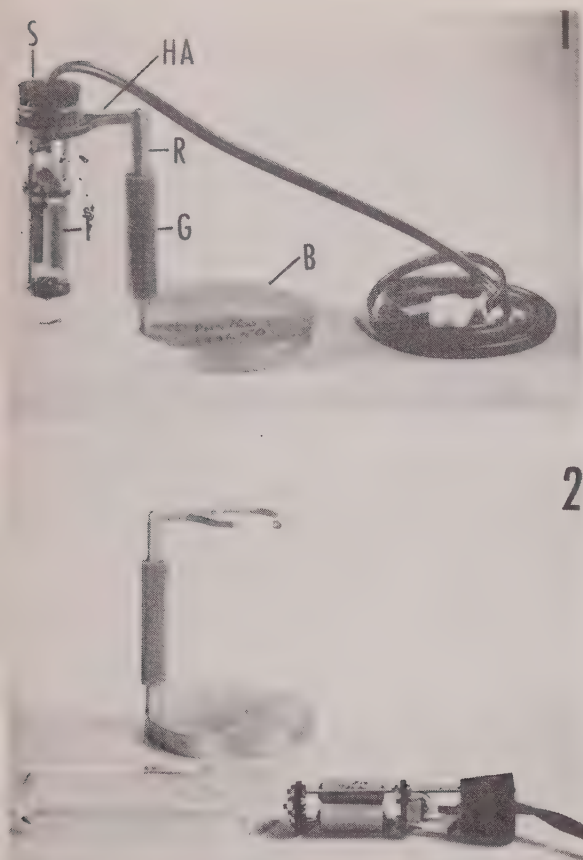
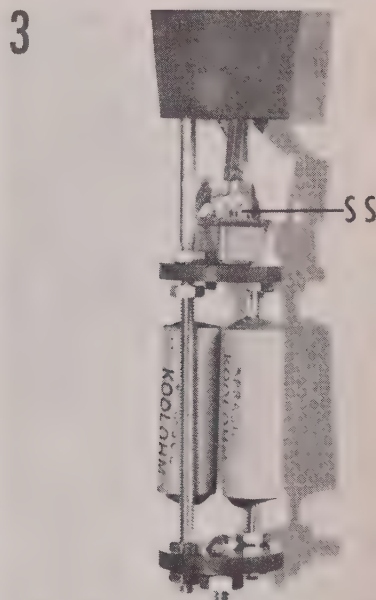


FIG. 1.—Assembled portable feeding unit showing base (B), upright arm (R), handgrip (G), holding arm (HA) and the thermostatic control (T) inserted into rubber stopper (S) and glass tube.

FIG. 2.—Disassembled feeding unit.

FIG. 3.—Details of the thermostat. The temperature regulating screw is shown at SS.



REARING INDIVIDUALLY ISOLATED MOSQUITO LARVAE¹

JAMES D. LONG AND OSMOND P. BRELAND

The University of Texas

There are many occasions which call for a simple, practical method of rearing large numbers of isolated, individual mosquito larvae for experimental purposes. A relatively simple device for isolating larvae for study purposes has been developed in this laboratory within the past few months. This device, known as a "float," makes possible the handling of a large number of larvae and eliminates many problems usually encountered.

The principal part of the float is a piece of Plexiglas, five by ten inches in size, and $\frac{3}{4}$ of an inch thick. This plastic, an acrylic polymer, is a product of the Rohm and Haas Company. Holes to be used for rearing chambers were bored through the plastic using a power drill with a $\frac{1}{2}$ inch bit. The holes were spaced $\frac{1}{2}$ inch apart, and arranged in five rows; each row has ten holes for a total of fifty in the piece of Plexiglas.

A piece of white nylon hose, 51 gauge, 30 denier, such as are worn by nurses and hospital attendants, was attached over one surface of the plastic. This closed one end of each of the holes which were then used as rearing chambers. It was found that the mesh was small enough to prevent the escape of first instar larvae, but large enough to allow free circulation of water and certain types of food material.

Duco cement, diluted with ethylene dichloride, was used in affixing the cloth to the plastic block. A small camel's hair brush was used in applying this adhesive. The cement was applied around each hole to insure that the separation of the chambers was complete, and to prevent larvae from being trapped between the cloth and the plastic.

In use, the float is suspended in an enamel pan with the side covered by the piece of hose on the under surface. Any of several methods of suspension may be used, and these will be mentioned shortly. Water is maintained in the container at a level where each compartment will be partially flooded. One larva is placed in each compartment which serves as a rearing chamber. Each compartment is numbered, and individual records are kept on the ecdyses of each larva.

When pupae appear, a small vial is inverted over each chamber and the adults are trapped as they emerge. Screw-top vials of the one dram size fit well in the openings and are used for this

purpose. A small strip of filter paper is placed in each vial to allow for a better resting surface for the emerging adults. Adults have been left in these vials for as long as two days without any apparent harm. The ease with which the adults can be handled in this way is an important factor.

It has been mentioned that the float can be suspended in the container in a number of different ways. In our first attempt, two empty bottles with screw-tops were attached to the block in such a way as to give it sufficient buoyancy to remain at the surface of the water. This required a large container of water, and the float, being movable, was awkward to operate. Later, small holes were bored in the corners of the piece of plastic and short pieces of glass tubing, approximately three inches long, were inserted in each. These rods serve as legs upon which the block of plastic is supported (Fig. 1). The water level is kept constant by using an inverted flask containing water as a reservoir. A tube runs from the flask to the surface of the water in the pan. When the water level falls below the end of the tube, air passes up the tube into the flask; this permits water to run into the pan replacing that which has evaporated. This method has proved to be satisfactory and it is the one now being employed.

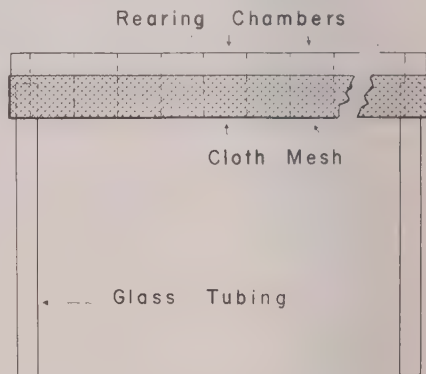


FIG. 1. Diagram of float, side view. The cloth mesh which covers the under surface is folded over and glued to the sides of the float to allow for better attachment.

¹ This work was done while working on a project supported by a research grant, E-507 (C2), from the Microbiological Institute of the National Institutes of Health, Public Health Service.

The methods used in supplying food to the isolated larvae have varied somewhat. If food materials such as *Paramecium*, powdered dried brewer's yeast, or Bates Medium S are used, they are

added directly to the water, since they easily pass through the mesh of the nylon hose. When larger particulate food, such as ground-up dog food, is used, it is added individually to each compartment. Detritus and wastes are removed daily from the chambers with a medicine dropper. Any foreign material or scum that collects on the surface of the water within the individual chambers is removed by drawing small squares of filter paper over the water's surface.

It has been found that there is less mortality among the larvae, both in mass and individual rearing, if the medium in which the larvae are reared is slowly circulated. This is provided for by compressed air; the air passes into a plastic tube and through an air stone into the water. The air stone is of the type often used in aquaria and which serves to disperse the air so that a series of fine streams pass into the water, forming many small bubbles. The air flow is controlled with a small needle valve. The water in which the float is suspended is circulated in this manner.

To prevent air from collecting along the under surface of the float, the air stone is placed at one end of the enamel pan, the float at the other.

The use of this float has many advantages. This apparatus is simple and requires only a small amount of space. A minimum amount of daily care is required and data are easily and speedily recorded. All of the materials used in the construction of this equipment are either plastic or glass and do not react chemically with any reagent normally encountered.

This equipment has been in use only for a few months and, as yet, has not been tested with a great variety of different kinds of mosquito larvae. Several species of *Culex* and one of *Culiseta* have been reared successfully in this fashion. The basic elements of this method are simple, however, and can easily be modified to fit different standards which experimentation may demand. With these reservations and comments, it is hoped that this technique can be further adapted for experimental purposes.

FLORIDA ANTI-MOSQUITO ASSOCIATION

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EDITORIAL

A significant meeting held in Atlanta, Ga., March 19-21, 1956, was a conference at the Communicable Disease Center of vector control specialists. As is stated in the foreword to the summary of this conference, the objective "was to provide those in attendance an opportunity to discuss informally what the problems are today in vector control and related fields in the states, what measures are being used currently to alleviate them, and how vector control services can be made more effective." Among those who attended this conference were many prominent members of the American Mosquito Control Association.

Like most conferences of professional workers, the panel discussions brought out many accomplishments in the fields under discussion. What is more significant in some respects was the listing in specific manner of some of the more important vector control problems on which there is not enough information, and on which additional research is urgently needed. In the belief that all AMCA members can profit by having in mind some of these points on which additional research is needed, they are cited verbatim from the Proceedings as follows:

1. The degree of thermal decomposition of organic phosphorus compounds as compared to the chlorinated hydrocarbon in-

secticides in thermal aerosol generators used in vector control operations.

2. The relative effectiveness of insecticidal dusts and fogs in vector control.

3. The biology and control of mosquitoes produced in the increasing numbers of sewage oxidation ponds and sewage lagoons throughout the nation.

4. Equipment for the effective airplane application of granular insecticides.

5. Equipment and techniques for high-rate aerobic composting of organic wastes.

6. The biology and control of mosquitoes in irrigated areas.

7. The biology and control of salt-marsh mosquitoes in coastal and inland areas where these species constitute a serious economic and nuisance problem.

8. A greatly expanded program of research on the problem of insect resistance to insecticides.

9. The overall operation of garbage and refuse storage, collection, and disposal.

10. A substantial expansion in research on the human toxicology of pesticides.

11. Pollinosis control techniques, materials, and equipment.

12. Basic investigations on the ecology, biology, and behavior of insects of public health importance as a guide to more effective use of existing control measures and to the development of new control approaches.

VIRGINIA MOSQUITO CONTROL ASSN.

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NEWS AND NOTES

MOST OF OUR CORRESPONDENTS HAVE BEEN BUSIER THAN THE TRADITIONAL MOSQUITO AT THE NUDIST PICNIC the last three months and so, as often happens, the News and Notes have all poured in all at once, the last thing and too late to classify. It reminds us of a story which has nothing to do with mosquitoes, though it appeared in the pep sheet of a mosquito abatement office of the U. S. Navy. It seems this somewhat meddlesome old lady phoned in a choice bit of gossip to the editor of the town weekly and added officiously that it simply *must* go into the next edition.

"I'll try to get it in," the editor is reported to have said, "but it's late and we're running a little bit tight."

"Well, I *do* think," snapped the lady, "That you could stay sober long enough to get the paper out!" (The editor of M. N. wonders if the editor of N & N is suggesting that is why *Mosquito News* comes out late.—Ed.)

But, as the mosquitoes said to the trout fisherman, "I guess we're boring you."

THE VIRGINIA MOSQUITO CONTROL ASSOCIATION REPORTS IN ITS ORGAN *The Skeeter*, that Hampton district has been using its salt marsh plow to good advantage despite their inability to find time to work it more than one day or so a week. In an average four working days, the equipment installed over 80,000 linear feet of salt marsh ditches 10 inches wide and 10 inches deep. That's no joke.

Skeeter ALSO REPORTS TWO ITEMS WHICH PERHAPS SHOULD BE LISTED IN OPERATIONAL NOTES rather than here. Norfolk, they record, needed a power sprayer for light usage which would be compact, light weight and inexpensive. A used surplus aircraft fuel pump of small size and with a 200 GPH rating, a feedback and a pressure regulator exactly filled the bill. It was driven with an automobile starter motor, which pulls very little current under light load.

WE DIDN'T CLEAR *Skeeter's* OTHER SUGGESTION WITH TODD but it sounds like a good idea. Western Branch District, in Virginia, has a TIFA mounted on a jeep and needed to make it convenient for 1-man operation. They mounted a slit-light on the Tifa panel and focused a small mirror on the jeep so that the driver can watch the Tifa instrument panel without throwing his neck out of joint and driving with only one eye, or less, on the road. Then, in order to save the jeep battery, taxed by slow driving and the resultant failure to recharge, they put an extra generator and voltage regulator on a mount that could be swung out of the way when it was not in use. Another pulley on the shaft of the hand starter on the Tifa (which spins anyway, during

use) gives the jeep battery an extra input of juice during fogging operations so that the battery gets charged same as usual.

SIX MOSQUITO CONTROL DISTRICTS IN VIRGINIA are again cooperating in a light trap operation, too. Under their plan, a collector is hired who visits every trap every day. The results of the collection, if unusual, are telephoned to the appropriate Supervisor that afternoon, permitting immediate action. The cost is only \$80.00 per trap per year, a very small charge for this Gallup Poll on program effectiveness.

EDWARD I. COHER, W.H.O. ENTOMOLOGIST IN NEPAL writes from Amlekhganj, % The Indian Embassy P. O., Kathmandu, Nepal, that the malaria control team of which he is a member has been meeting with some little success in its efforts. They have incriminated the vector species, added a couple of anophelines not previously listed for Nepal and conducted a blood survey and spray survey for the Rapti Valley, which is just north of the Siwalik Range and lies at an altitude of about 520 meters. They have been using wettable DDT with apparent good effect, despite the fact that it was thought by some that this material would not work in that region. They credit George Burton, who has also written from Nepal, with getting the Nepalese Government supplies which WHO has been using. Ed's mail address is 557 California St., Newtonville, Mass.

GEORGE BURTON HIMSELF WRITES, ALSO FROM NEPAL, that despite his pleasant remarks on travelling about on anything from his feet to an elephant, the entomological travel picture isn't all rosy there. For one thing there are airplanes. These seem like a modern method of transportation, but the catch is that the airports, if we "give them the benefit of the doubt and call them that," are irregular grassy fields. During the monsoon these are presumably suitable for some mosquitoes but not for airplanes. Nevertheless the airplanes, and George, use them with insouciance and determination respectively. George reports that he is still knocking 'em down with his dieldrin spray program, though people who had become used to the whitewashing effect of wettable DDT were inclined to be skeptical of anything they couldn't see on the wall. These skeptics came around when they found that they could sleep without mosquito annoyance. The spraying has continued, though slowly, throughout the monsoon.

ENTOMOLOGISTS AND ENGINEERS ARE URGENTLY NEEDED IN ASIA AND AFRICA, WRITES DON JOHNSON, to underline statements previously made here.

The U. S. Public Health Service is recruiting to fill several vacancies in malaria and filariasis control programs supported by U. S. International Cooperation Administration. Liberal salaries plus free housing, allowances and transportation for employees and family are provided. Most assignments are for two years with option of renewal after home leave in U. S. Several one-year assignments also are available. If you are a U. S. citizen experienced in mosquito or malaria control, have a patriotic desire to assist our government in its foreign program, and have a yearning to travel to "far away places," send a brief summary of your education and experience to the Division of International Health, Public Health Service, Department of Health, Education, and Welfare, Washington 25, D. C.

THE CALIFORNIA MOSQUITO CONTROL ASSOCIATION has issued its 1956 Yearbook, a very fine job of printing and of compilation which lists all the people in that state who are concerned in the mosquito abatement program. Insecticides used in each section of the state are tabulated quantitatively and a summary of the 1955 program of mosquito source reduction is given. There is also a nice write-up of the AMCA and source material on our activities and structure.

CHET ROBINSON OF THE ALAMEDA COUNTY (CALIFORNIA) MOSQUITO ABATEMENT DISTRICT writes that no measurable rain fell during June but this did not help him a great deal in his mosquito abatement workload. Above average hot weather, interspersed with normal, cool days for emphasis, caused an increase in the number of people who sought relief on the hot days by running around their barbecue pits in shorts and otherwise exposing themselves to the mosquitoes, many of them the tree-hole breeder, *Aedes varipalpus*, which was still around. Trouble calls were also increased by the psychosomatic injuries received by householders from chironomid midges which they mistook for mosquitoes. Well, anyway, Chet, the worst is over for this year.

A RESIDENT OF MAPLEWOOD, N. J., AND WE GUESS A CUSTOMER OF ONE OF OUR MEMBER ASSOCIATIONS, A MR. JACOB ROSIN, HAS BECOME TIRED OF ALL THIS TALK ABOUT HOW DANGEROUS INSECTICIDES and such useful chemicals are. He has suggested that the compendium of dangerous, hazardous and toxic materials be enlarged to include:

Oxygen

A very toxic gas and an extreme fire hazard. It is fatal in concentrations of only 0.000001 p.p.m. Humans exposed to these oxygen concentrations die within a few minutes. Symptoms resemble very much those of cyanide poisoning (blue face, etc.) In higher concentration, e.g. about 20%, the toxic effect is somewhat delayed . . . the main disadvantage of the 20% oxygen concentration is that it is habit forming. The

first inhalation is sufficient to make oxygen addiction permanent. . . . High oxygen concentration provokes in prematurely born babies . . . a condition known as retrolental fibroplasia, resulting in blindness. Lung irritation has been reported on experimental animals. . . .

Oxygen is an extreme fire hazard. All the fires reported in the continental U. S. for the period of the past 25 years were found to be due to the presence of this gas in the atmosphere surrounding the buildings in question.

Oxygen is especially dangerous because it is odorless, colorless, and tasteless, so that its presence cannot be readily detected until it is too late.

CAPTAIN CARLYLE NIBLEY of the 4th Army Area Medical Laboratory is winding up some extremely interesting experiments with colored lights and lights of varied intensities in mosquito light traps. Done in collaboration with Westinghouse, the results may lead to a considerable improvement in our knowledge of the mechanism and usefulness of light traps. They will be written up for later full-scale publication. Meanwhile, Nibs is preparing to take time off for a return to school for further degrees, at the University of Maryland.

MR. E. ELWOOD LYNCH, Mosquito Control Engineer, formerly with the State Highway Department of Delaware, has accepted the position of Chief Engineer on the Maryland State-wide Mosquito Control Project that was initiated on 1 July, 1956.

A.M.C.A. HAS AMONG ITS LISTS NOT ONLY MANY PROMINENT INDIVIDUALS BUT SOME OF THE MOST MODEST FOLKS WE EVER RAN ACROSS. AFTER TIRELESS EFFORTS TO EXTRACT BIOGRAPHIES OUT OF THEM AND OUT OF *American Men of Science* AND OTHER SOURCES, HOWEVER, WE'VE MANAGED TO DRAG THE TRUTH OUT OF A FEW MORE FOR YOU. . . .

BILL BICKLEY PROBABLY HEADS THE LIST FOR MODESTY because in response to our inquiry for more info he characteristically sent us a lot of good words about some other people he knows. Bill feels his greatest success in AMCA has been choosing capable successors to his manifold jobs, whereas his successors know that, however pleased they may be at the compliment, being Bill's successor means the job has already been thoroughly organized and success is almost automatic. Well . . . Dr. Bickley was born in Knoxville, Tennessee, on 20 January, 1914, and received his B.S. from the University of that State in 1934. His PhD. was awarded by Maryland in 1940 and he has taught there for the past seven years or so. He previously taught at the University of Richmond between 1946 and 1949, during which time he was a consultant to the State Health Department. He was commissioned in the U.S.P.H.S. during the war, being assigned to Malaria Control in War Areas in Virginia. The P.H.S. is also responsible for a grant in aid which Bill ad-

ministers and an Army contract in research, but Bill's discussion of this branches off onto other people so much that we'll put it in a separate place. A description of a new species of mite, which will appear in the August number of the *Proceedings* of the Entomological Society of Washington, will give the name *Garmania bickleyi* to the literature, in honor of Bill.

ARCHIE D. HESS WAS BORN IN OKLAHOMA CITY, Oklahoma on 11 January, 1911, but grew up on a ranch in Colorado and received both his B.A. (1932) and his M.A. (1933) from Colorado College. His Doctorate was awarded by Cornell in 1939 during a four year period with the New York State Agricultural Experiment Station and as an Instructor at Cornell U., ending in 1940. Although Archie is chiefly associated in most of our minds with T.V.A. and the U. S. Public Health Service, he has actually distinguished himself at several other tasks as well, including a period as a travelling fellow in Central and South America for the Rockefeller Foundation and two years as Chief Malarialogist for FOA in the Philippines where he organized the program so capably continued by another AMCA member, T. V. McNeel. This program, which gave scientific proof to a contention on which the Army had based its post-war control program, demonstrated the feasibility of malaria control by house spraying and measures other than species eradication, and reduced malaria some 80 percent. Well over a million homes were sprayed annually and protection was afforded to above five million people. Especially important was accomplishing the malaria control before resistance arose. Archie is a member of Phi Beta Kappa, Sigma Xi, Delta Epsilon and a large number of learned societies concerned with entomology, public health and tropical medicine. He is also a member of the National Research Council and of the Expert Committee on Insecticides for WHO.

FRED L. SOPER was born in Hutchinson, Kansas, in 1893 and received his A.B. in 1914 and his M.S. in 1916 from the University of Kansas. He received an M.D. from Rush Medical College of the University of Chicago in 1918 and a doctorate in Public Health in 1925 from Johns Hopkins. From 1920 to 1942, he was with the Rockefeller Foundation, most of that period being Regional Director of the International Health Division, headquartered in Rio de Janeiro. During this time an eradication method against *Aedes aegypti* was developed and this was later used effectively against *A. gambiae*, which got a brief toehold in Brazil in 1939 and 1940. Fred was consultant to the Secretary of War from 1942 to 1946, a period which included a term as head of the Rockefeller Foundation Health Commission Typhus Team in North Africa and Italy. In addition to the eradication of typhus in Naples and malaria control demonstrations for the Allied Military Government in Italy, he was also instru-

mental in the eradication of *Anopheles gambiae* in Egypt, which was done at the request of that Government. Dr. Soper was Regional Director of the International Health Division, headquartered in Cairo, in 1946 and in 1947 became director of the Pan-American Sanitary Bureau, to which position he has been reelected at each succeeding Pan American Sanitary Conference. Since 1 May, 1949, this Bureau has also served as Regional Office for the Americas of the W.H.O. Fred has received awards from a good many foreign Governments, including Cuba, Brazil and Egypt, and has also not been unnoticed by our own Government and our learned Societies and Academies. In 1955, his most recent honor, the degree of Doctor of Science, was awarded by the Jefferson Medical College in Philadelphia.

ROY F. FRITZ, who is currently the Chief, Vector Borne Disease Unit, Epidemiology Branch, Communicable Disease Center, USPHS, Atlanta, Georgia, was born in 1915 in Oakland, California and received his BS and MS there in 1937 and 1939, respectively. In 1948 he returned and earned another MS in Public Health (MPH, that is), but meanwhile he had been assistant entomologist at the Kansas Agricultural Experiment Station, entomologist at MCWA of the USPHS in Atlanta, Ga., during the war years, and worked on typhus control. Following his studies at the University of California in 1947 and 1948, he was with the California State Department of Public Health and then returned to the USPHS in 1950 in San Francisco, before being made Chief of the Mosquito Control and Investigations Section of the CDC. His findings on the transmission of a freak outbreak of malaria in California were justifiably widely publicized, and provided us with needful knowledge that the theoretical can actually happen, sometimes. In 1954, Roy was an observer and consultant in Trinidad, during the outbreak of jungle yellow fever and in 1955, he went to Liberia to observe the program there, returning through Lisbon, Paris and London. In the latter place he conferred with the research men of the famed London School of Tropical Medicine. Since September 1955, he has been connected with the campaign to eradicate malaria in Mexico, under the chiefship of Dr. Luis Vargas' Office of Evaluation (cf. *Mosquito News*, News and Notes, Vol. 15, No. 1, p. 54). Some people sure get nice assignments.

FRANKLIN C. WRAY is the Technical Director of the Desplaines Valley Mosquito Abatement District, which has been giving us such interesting notes over the past few years. Frank was born in 1908 at Chicago and received his A.B. from Marietta College, Ohio, in 1931 and his M.S. from the University of Chicago in 1933, in the Department of Geology and Paleontology. He has been acting Secretary-Treasurer and President of the reorganized Illinois Mosquito Control Association, and Regional Director of the A.M.C.A. for the North Central Region.

DONALD GRANT, Manager-Entomologist of the San Mateo County Mosquito Abatement District, under whose presidency the California Mosquito Control Association gave us such a memorable joint meeting a couple of years ago, says he was determined to be a biologist and entomologist by the time he was old enough to read, and used to practice up for his future profession by collecting trips in which he packed back into the High Sierras, a now almost-obsolete sport. He started his ten years at Stanford in 1938. (was it really ten years, Don, or did it just *seem* like ten?) and received his B.A. in 1942. In the Army for 3 years, Don did lab work in England and France and returned to Stanford for his M.A. in 1947 and thereafter completed all but his thesis on a Doctorate. He is still working on this thesis, which is on parasitic mites, not mosquitoes, but meanwhile he is also becoming a leading authority on the non-culicine Diptera which complicate mosquito control so thoroughly in California. In addition to his membership in the AMCA and CMCA, Don is a member of Sigma Xi, the Society of Systematic Zoologists, the Pacific Entomological Society, and the Entomological Society of Washington. His efforts at developing reliable local mosquito abatement programs in his District have been so successful that residents talk about "the mosquitoes we had ten years ago," as if they had been all swept away by a cataclysmic Act of God. Man, *that's control!*

THE ARMY CONTRACT BILL RICKLEY is ADMINISTERING enables his students to continue an investigation which they have been pressing on the role of mosquitoes as vectors of filariasis in six wild mammals in the Maryland area. They will be using skunks, raccoons, opossums, woodchucks, rabbits and squirrels in the study, and suspect *Aedes triseriatus* as one of the vectors, possibly a major one. Altogether there are 8 graduate students working on medical entomological problems at Maryland, Bill writes, and last semester saw 11 students enrolled in the course on mosquitoes. Bill not only scours the woods for members . . . he grows 'em.

DON JOHNSON AND HIS MEMBERSHIP COMMITTEE are scouring the woods for mosquito-hating members, too, according to a notice we have received. Regional Directors and other influential members are being canvassed in this drive and all members are urged to join right in and help. Our Association is big and strong and widely representative, but it will never be big enough or strong enough or wide enough until every worker in the field of mosquito control is enrolled. Actually, no worker in the field worth his salt can afford to remain on the outside looking in and it shouldn't be so hard to convince him of this fact. Mainly, it's knowing who's in and who ain't. Members are urged to scan their recently-received lists of members, give their cohorts and mosquito-

abatement acquaintances the double-o and whip out the little old yellow slips for membership. If you receive a communication from the membership committee, pray you gentlemen do not ignore it, and if you don't receive one feel not slighted but arm yourself with application blanks and *dig in!*

THE CALIFORNIA BUREAU OF VECTOR CONTROL held its Annual Staff Meeting on 21, 22 and 23 August, and listed some mighty vital discussion subjects, to say nothing of a very enjoyable picnic, held in Dick Peters' backyard. Informal and practical discussion was stressed rather than prepared papers. Dick's country estate is named "Back Acres," incidentally, but we don't think he means it unkindly.

ARCHIE HESS IS LIKEWISE THE SPONSOR of a very stimulating discussion group, one which met in Salt Lake City on 30 and 31 August and 1 September. The general topic of the meeting, which was an international one, was diseases occurring in nature and communicable to man, with particular reference to the Northwest. Sections covered such wide topics as arthropod-borne virus encephalitides, plague in Western North America, ecology of arthropod borne diseases, polio, rabies and other viruses and other major problems in which much more remains to be learned than has yet been discovered.

RECENT PROGRESS OF MOSQUITO WORK IN JAPAN. (From a letter from Dr. Teruhiko Hosoi to Archie Hess). "Despite the intensive control projects carried out after the war, urged by and under the supervision of U. S. Army officials, Japan has not had much success in eradication of pest mosquitoes. It is true that flies and mosquitoes have diminished in some cities, but in the suburbs and country areas they are still abundant everywhere. Last year, Chief of the Government Public Health Bureau drew up a three-year program of fly and mosquito extermination. However, the budget approved by the National Diet was miserably small. Health officials of cities and towns also had to face the similar economic disadvantage. The worst of all is that in our country cooperation is lacking among the different systems of organizations. Exploitation jobs or industrial constructions are undertaken before any consideration is paid to public sanitation. Main duties of the health officials are only to spray insecticides over the breeding places which are constructed anew every day.

"In one field, however, we have made fairly good progress during the last decade. That is civil instruction about insect borne diseases. Nowadays a majority of our nation knows how mosquitoes carry encephalitis and malaria and where these insects are breeding. Pupils of the primary schools are the most earnest operators in control works. They could have killed all the mosquitoes around their houses if there were no pools, marshes, paddy fields and irrigation ditches in those areas.

"Now I will turn to research works in our country. At present, most of our investigators on mosquito problems are joined to the Japan Society of Sanitary Zoology, which was separated from the Japan Society of Parasitology several years ago and held its first annual meeting in 1949. The society includes those who study arthropods and rodents of medical importance. Abstracts of articles read at the annual meetings and also some original papers have been published in the *Japanese Journal of Sanitary Zoology*, a representative periodical dealing with mosquito works in Japan, the first volume of which was issued in 1950. On the whole, mosquito studies are subsiding recently, being replaced by studies on other subjects, i.e., those on simuliids, Trombicula mites and wild rodents.

"Immediately after the war, people were warned of malaria epidemics, so that an *Anopheles* survey was taken, of urgent necessity. Otsuru worked on several subgroups of *Anopheles hyrcanus sinensis* and its allies and discussed their bearing on transmission of tropical malaria. Meanwhile the danger of malaria epidemics passed, but the problem of *sinensis* control remained unsolved, because this species breeds in paddy fields where control of water resources is extremely difficult. It seems curious that in the recent years Japanese workers are not much interested in B encephalitis transmitters. The problem has been mostly studied at U. S. Army medical laboratories. *Culex tritaeniorhynchus*, suspected to be the most important vector, breeds also in paddy fields; accordingly the control is by no means easy. Its hibernation habit is not yet known. Moreover, no one has succeeded in raising this mosquito through several generations in the laboratory.

"During these years, Sasa, Asanuma, Yamaguti and others engaged in taxonomic description of culicine and aedine mosquitoes. The revisions made rapid progress; consequently it facilitated mosquito surveys a great deal in various local

districts. Indeed, mosquito surveys have occupied a considerable percentage of sanitary entomologists throughout the last several years. The results will undoubtedly benefit future control projects. However, actual eradication works have not been so much investigated as would be required. Bringing up good engineers requires good politics. A light trap of the New Jersey type has frequently been employed in our country also. With the aid of this trap Nakata confirmed at Kyoto that many mosquitoes could migrate as high as 50 metres over the city ground. While engaged in revision of Japanese mosquitoes, Sasa also undertook filaria survey and, in cooperation with Hayashi, discovered *malayi* filariasis in a small island near Hachijo. This is the first record of *Microfilaria malayi* from Japan.

"The *Culex pipiens* complex was studied particularly by Omori and Abe. In Kyushu mixed populations of *C. pipiens pallens* and *C. fatigans* (= *C. quinquefasciatus*) have been established. Abe says that apparently typical *pipiens pallens* or *fatigans* produced some intermediate forms after succession of generations in the laboratory. An autogenous form of *molestus* type is also reported from Honshu and Kyushu. On the other hand, systematic investigations on closely allied species are being carried out from a synecological point of view. Among these works Kato's are outstanding.

"I have been interested in the physiology of hibernating adult mosquitoes. In relation to this study it became prerequisite to know the nutritional requirements of females. The work met with difficulty of feeding the insect on artificial meals which contain neither sugar nor blood corpuscles. Recently I was able to extract from ox erythrocytes a certain substance, which contained no hemoglobin but still retained a stimulating effect of inducing the mosquito to suck a dilute saline solution of it into the stomach as if a suspension of intact erythrocytes."

OUT-OF-PRINT PUBLICATIONS AGAIN AVAILABLE

The New York State Museum announces that many out-of-print items from its stock of publications from the State Entomologist's office have recently been made available. A list of these publications, together with more recent titles, may be obtained from the office of the State Museum, State Education Bldg., Albany, N. Y. There are some 64 titles, beginning with Lintner's report on the May beetle, dated 1888, and including the several memoirs and circulars on aquatic insects by Needham, Johannsen, Felt, Metcalf and Sanderson, Betten, and others.

REVIEWS AND ABSTRACTS

MOSQUITOES OF NORTH AMERICA. Carpenter, S. J. and LaCasse, W. J. 1955. Berkeley, Calif. University of California Press. 360 pp. \$10.00. The amount of good, sound information concentrated in this one volume is impressive. We cannot resist the impulse to compare the wealth of information found in this one book with that available in several publications twenty, or even five years ago.

The first 7½ pages outline the life history of mosquitoes, the method of collecting adults, larvae, and eggs, and the preparation of specimens for study. This is followed by 15 pages on external anatomy and 1½ pages on internal anatomy. The next 305 pages are devoted to descriptions and keys to subfamilies and tribes and to the eleven genera and 143 species and subspecies found in North America north of Mexico. Under each species is a list of synonyms, descriptions of the female, male, and larva, and paragraphs on geographical distribution, bionomics, and on medical importance. With a few exceptions, each species is illustrated by line drawings of the male terminalia, and by one of larval characters, including in apparently every instance the larval terminal segments and head, comb scale and pecten tooth, and sometimes the thorax. Pupae are not keyed or described.

The excellent drawings are an outstanding part of the book; they are a stimulus to the student of taxonomy and an encouragement to the specialist in other fields of culicidology. Two of the text figures were taken from publications by Ross and Roberts and by Penn, others from the 1946 monograph by Carpenter, Middlekauff, and Chamberlain, and the remainder were drawn by members of the Taxonomic Entomology Section of the 406th Medical General Laboratory in Japan, and by Eustorgio Mendez and Reginald Jones. Full-page plates of the females of 127 species are found at the end of the book. They were drawn by Saburo Shibata, Kei Daishoji, and Kakuzo Yamazaki, also of the Taxonomic Entomology Section in Japan.

The geographical distribution of species is listed by state and by Canadian province, and the data are well-documented.

It should be remembered that the value of this work lies in its authoritative presentation of facts for mosquito identification, and that the bionomics and medical importance of the species are, with a few exceptions, treated briefly. The authors have provided a splendid bibliography, including numerous references for specialists in fields other than taxonomy. We recommend that the bibliography of 770 titles be read as carefully as the text.

The systematic index is arranged so that valid genera and subgenera appear in bold type, valid species in roman, and synonyms in italics. This is

helpful, not only to the student, but to the worker preparing manuscript. Indeed, we could have used a similar guide to world species during the compilation of AMCA Bulletin No. 3!

This is a large book, approximately 9 by 11 inches, but it is thin enough, 1½ inches, to fit into a crowded briefcase; and it is lightweight enough to be carried in the field. Its strong, well-printed pages and sturdy binding should give years of good service; and its concise, comprehensive contents merit its placement on the shelves of every office or laboratory where mosquitoes or mosquito-borne diseases are being investigated.—H. L. T. D.

THE MOSQUITO FAUNA IN SELECTED SWAMP AREAS AT THE PATUXENT RESEARCH REFUGE, MARYLAND IN 1955. Joseph T. Whitlaw, Jr. Unpublished M.S. Thesis, University of Maryland. 38 pp. 1956.

Two similar swampy areas on the Patuxent Research Refuge were studied from April to November, 1955 to determine their mosquito fauna. The fourteen acre check area would remain unpounded. Plant species are designated with observations on relative abundance. Each week larval populations were estimated by dipping; 1,421 larvae were taken in 2,100 dips in the study area; 284 larvae were taken in 280 dips in the check area. Adult populations were estimated by recording the number landing on the author in stated periods. Nocturnal biting collections were made also. An estimated total number of 425 adults were collected during 287 minutes in the study area, while 46 adults were collected during 35 minutes in the check area. Stations in the areas were designated to insure an adequate sample. Precipitation data are given.

The three species of larvae collected, listed in order of abundance, in the study area were: *Aedes canadensis* (Theobald), *Culex territans* Walker, and *Aedes vexans* (Meigen). In order of abundance, the six species of larvae dipped in the check area were: *Aedes canadensis*, *C. territans*, *Anopheles punctipennis* (Say), *Aedes vexans*, *Anopheles crucians* Wiedemann, and *C. restuans* Theobald. The ten species of adults collected in the study area listed in order of abundance were: *Aedes canadensis*, *Aedes vexans*, *Psorophora ferox* (Humboldt), *Aedes trivittatus* (Coquillett), *Mansonia perturbans* (Walker), *Anopheles punctipennis*, *Aedes triseriatus* (Say), *C. pipiens* Linnaeus, *C. salinarius* Coquillett, and *P. ciliata* (Fabricius). In order of abundance, the nine species of adults collected in the check area were: *Aedes vexans*, *P. ferox*, *Aedes trivittatus*, *Aedes canadensis*, *Anopheles punctipennis*, *Aedes triseriatus*, *M. perturbans*, *Aedes sollicitans* (Walker), and *C. restuans*.

Larvae of *Aedes canadensis* were found on three separate occasions in the same station following the drying up of the station. After these drying periods, of varying time lengths, the station was thrice inundated and found to contain larvae of this species.

An increase in larval production followed torrential rains during August, 1955. Prior to these downpours the areas were nearly dry, and larval production had fallen to zero.

Collectively, because of the large acreage they occupy on the Refuge, swamp areas such as those studied probably constitute important sites for mosquito breeding. Outside the swamps mosquitoes were not particularly annoying, and this fact would seem to indicate that the dispersal range of the mosquitoes breeding in the swamps was not great.—Wm. E. Bickley.

THE ATTRACTIVENESS OF SIX MAMMALS TO MOSQUITOES AT THE PATUXENT RESEARCH REFUGE IN THE SUMMER OF 1955. Neville Karunasena Rajapaksa. Unpublished M.S. Thesis, University of Maryland. 37 pp. 1956.

Six different species of mammals were used as bait to attract mosquitoes, at the Patuxent Research Refuge, Laurel, Maryland, in the summer of 1955. The traps used were designed by Captain Donald L. Price of the United States Army Medical Service and were a modification of the type used by Magoon in 1935.

The traps were located in two widely separated wooded areas on the Refuge. A total of 124 specimens belonging to eight species were represented in the catches. *Aedes triseriatus* Say., *Aedes vexans* Meig., and *Psorophora ferox* Hum. were the dominant species. Also collected were *Aedes canadensis* Theo., *Anopheles crucians* Wied., *Anopheles punctipennis* Say., *Mansonia perturbans* Walker, and *Culex pipiens* L.

Aedes triseriatus was not collected at night confirming previous reports that this species is crepuscular. *Psorophora ferox* was collected from August 11th to September 3rd.

There was no significant difference between the attractiveness of the raccoon, woodchuck, skunk, possum, and squirrel to the mosquitoes known to be present. The rabbit was found to be significantly less attractive than the other mammals.

Details of numbers and species of mosquitoes attracted to each mammal are given. Each animal was exposed for six 24-hour periods. The experiments were conducted from July 17 to September 6, 1955.—Wm. E. Bickley.

AN ECOLOGICAL STUDY OF THE MOSQUITOES OF SNOWDEN POND, PATUXENT RESEARCH REFUGE, MARYLAND. Richard A. Boettcher. Unpublished M.S. Thesis, University of Maryland. 35 pp. 1956.

The mosquito fauna of Snowden Pond was studied from November 1954 to November 1955. The seven and one-half acre impoundment was

completed in 1947. Descriptions are given of the types and abundance of vegetation. Dipping was carried out at weekly intervals at twenty-six designated stations. Larval collections were supplemented with light-trap and biting collections. Water level fluctuations were recorded.

A total of 2,190 mosquito larvae were collected during the course of 14,617 dips. Species dipped, listed in their order of abundance were *Aedes canadensis* (Theobald), *Culex restuans* Theobald, *Anopheles* spp., *Culex* spp., *Culex erraticus* (Dyar & Knab), *Culex territans* Walker, *Anopheles crucians* Wiedemann, *Uranotaenia sapphirina* (Osten-Sacken), *Anopheles punctipennis* (Say), and *Anopheles quadrimaculatus* Say. *Aedes canadensis* is recorded for the first time from a fresh-water impoundment. Larvae of this species, which constituted 58 percent of the total, were dipped most often in small pockets at or near the head of the pond. Eggs may have been washed down with debris from wooded slopes.

Culicine larvae were collected most frequently in small marginal pools, while anopheline larvae were dipped most often in thick stands of emergent vegetation.

A rise in water level was found to be conducive to increased larval production. A two-weeks time lag usually occurred between the rise in water level and the rise in larval population.

Snowden Pond was not found to be an important source of pest mosquitoes.—Wm. E. Bickley.

THE SALINITY TOLERANCE OF FOUR SPECIES OF MOSQUITO LARVAE WITH SPECIAL REFERENCE TO THE LENGTH OF THE ANAL PAPILLAE. Michele Williams. Unpublished M.S. Thesis, University of Maryland. 42 pp. 1952.

Twelve solutions were used in which amounts of calcium and magnesium sulfates were kept constant but sodium chloride varied. The maximum salinity in which *Culex pipiens* L. could exist was 1.35 percent sodium chloride; *Aedes aegypti* L., 1.00 percent; *Culex restuans*, Theo., .85 percent; *Aedes atropalpus* Coq., .60 percent.

Culex pipiens larvae reared in 1.25 percent sodium chloride had anal papillae approximately one-fourth the length of those reared in distilled water. An extreme reduction in length of papillae of *C. restuans* occurred above .50 percent. *Aedes atropalpus* showed a progressive but not striking reduction up to .50 percent. Papillae of *A. aegypti* in .05 percent sodium chloride were about half the length of those in distilled water but did not become shorter in higher concentrations.

Confirmation is given to the view of Koch and Wigglesworth regarding the function of "anal gills." Larvae of *A. aegypti* had the same limit of tolerance for potassium chloride as for sodium chloride. The anal gills of *C. pipiens* and *C. restuans* behave in a similar manner.

An "overcrowding" effect in distilled water may shorten the anal gills of *A. aegypti* in a similar manner as dissolved salts.

Lethal concentrations of salt for fourth instar larvae of the four species are given.

The pupae of six species of mosquito larvae seem to be independent of the salinity of the water and will transform to adults in water containing up to 3.00 percent sodium chloride.—Wm. E. Bickley, University of Maryland, College Park, Md.

THE AMINO ACIDS REQUIRED FOR EGG PRODUCTION IN *Aedes aegypti*. By J. B. Dimond, A. O. Lea, W. F. Hahnert, Jr., and D. M. DeLong. *Canad. Ent.* 88 (2): 57-62. 1956. Four day old *Aedes aegypti* females, which fed on 10 percent glucose, were offered various combinations of amino acids on pads of cotton in groups of 400. The number of eggs laid over a 14 day period were counted and the various diets then compared.

Under these conditions the following 11 amino acids were found to be essential for a high level of egg production: (1) arginine, (2) *l*-isoleucine, (3) *l*-leucine, (4) lysine, (5) *l*-phenylalanine, (6) *l*-threonine, (7) *l*-tryptophane, (8) *l*-valine, (9) *l*-histidine, (10) *l*-methionine, and (11) cystine. No eggs were produced when any one

of the first 8 amino acids was omitted from the diet. D-histidine was as effective as the *l*-isomer. But *d*-isomers of methionine, phenylalanine, and tryptophane were not as good as the *l*-forms. The *d*-isomers of isoleucine, leucine, threonine and valine were apparently non-usable forms. The five amino acids not essential to egg production were (1) alpha alanine, (2) aspartic acid, (3) proline, (4) serine, and (5) tyrosine.

The authors state that "... at an equivalent nitrogen level, blood is a poor medium for egg production as compared to amino acid mixtures."

A major finding is that the qualitative amino acid requirements for egg production are essentially the same as those necessary for larval growth.

What part, if any, bacterial contamination (deamination) of the diets may have played in this study is hard to evaluate. Presumably the mixtures were contaminated by bacteria able to alter the composition of the diets. No indication is given as to whether the mosquitoes fed equally well on all mixtures. Especially in cases where no eggs were laid this information seems desirable. A comparison between the numbers of viable females over the two week testing period is not given, but presumably they are approximately equal.—Jack Colvard Jones, National Institutes of Health, Bethesda, Md.

CALIFORNIA MOSQUITO CONTROL ASSOCIATION, INC.

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Plant Pest Control Branch, Agricultural Research Service, United States Department of Agriculture

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Errata

Mosquito News 15(4):252, 1955. Section on Distribution, under Britz, L., change 6(1):61-79 to read 1:61-79, on same page under Taxonomy, change Desinova to read Denisova; p. 253 under Filariasis change Jackowski to read Jachowski.

Mosquito News 16(1):46, 1956. Section on Taxonomy, under Senevet, G. and Andarelli, L. 1955, add Abonnenc, E. On page 47 (the reference following this correction) the blank line still refers to Senevet and Andarelli. Page 179, 16(2), under Biology and Ecology change Jackowski to read Jachowski; on same page under Distribution change pagination of Thurzo to read 370-371.

UTAH MOSQUITO ABATEMENT ASSOCIATION

Districts: Box Elder County, Davis County, Magna, Salt Lake City, South Salt Lake County, Weber County

Sixty per cent of the people in the state of Utah are now living within the boundaries of organized mosquito abatement districts.

For Proceedings of annual meetings and other information write Lewis E. Fronk, Sec.-Treas., Utah Mosquito Abatement Assoc., 2441 Grant Ave., Ogden, Utah